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PETROLEUM MOTOR-CARS

PETROLEUM
MOTOR-CARS

BY

LOUIS LOCKERT

ILLUSTRATED

LONDON
SAMPSON LOW, MARSTON & COMPANY
LIMITED
St. Dunstan's House
FETTER LANE, FLEET STREET, E.C.
1898

Richard Clay & Sons, Limited,
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Transport

INTRODUCTORY

THE work which our colleague M. Lockert has felicitously dedicated to the Touring Club of France comes, in our opinion, in the nick of time, and supplies a want in our technical literature that has been keenly felt by the numerous lovers both of the cycle and the horseless carriage. The motor-cycle—steam, petroleum, and electric cars are, in fact, about to enter definitely into our daily life.

People who two years ago would have been horrified at the very mention of travelling at a speed of 30 kilometres (18½ miles) an hour on a steam-car, now look on calmly, if not with envy, as they see careering along, omnibuses, brakes, and victorias built by Serpollet, Levassor, or Peugeot.

The cycle has brought with it a taste for long spins in the open air, and along the country roads; it has increased our natural horror of the huge structures upon wheels, in which we do not know which of many inconveniences is the most

objectionable, the promiscuous nature of the company, or the dust, smoke, etc.

On the other hand, how much more agreeable is it for a party of four or five to take their ride in a good phaeton, or a comfortable, well-built victoria, hung on easy springs, and propelled by steam or petroleum, it matters little which.

We can thus enjoy the fresh air and the sunshine, the latter tempered by the rapidity with which we travel; there is no horse to groom and harness, and no train to catch.

A few tanks of water and sacks of coke, a few litres of petroleum, and we are always in readiness.

What then are we waiting for?

Is it the price of these vehicles that deters us?

It would hardly seem so, for the cost is very moderate.

Is it the idea of having to control a new and imperfectly known motive power, that causes a certain amount of apprehension, possibly fear?

This seems more probable.

And for this reason we recommend to all tourists and lovers of free and rapid locomotion a perusal of the *Treatise on Auto-cars on the Road.*

The author, M. Louis Lockert, was one of the earliest workers in the cause; years ago, when at the École Centrale des Arts et Manufactures, with René Olivier, he calculated the dimensions and

designed the outlines of some of the earliest bicycles for Michaux.

Since then he has devoted himself more particularly to the study of petroleum motors and their application to horseless carriages.

His work, which is divided into four volumes, is read with satisfaction by all amateurs of automotive touring—

Vol. I. Cycles.

Vol. II. Steam Motor-cars.

Vol. III. Petroleum Motor-cars.[1]

Vol. IV. Motor-cars worked by electricity, compressed air, carbonic acid, etc.

Each volume is of the usual library size, and as it can easily be carried in the pocket, should henceforth constitute the *vade mecum* of every tourist, according to the kind of motor that he favours.

A. BALLIF,

President of the Touring Club of France.

[1] This is the volume now presented to the British public.—Sampson Low, Marston & Co., Ld.

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THE FUTURE OF AUTO-LOCOMOTION

THE application of Motors worked by hydro-carburets to the propulsion of auto-motor-cars, as well as the construction of these motors, more especially petroleum motors, is, at present, in an initial stage; it is therefore no easy task to write on a subject as yet undefined, and which is just in that state of indecision and uncertainty that when we have started we find that we have acquired just sufficient experience about direct combustion motors to enable us to fully recognize their defects, and to feel the necessity for introducing improvements.

It is no exaggeration to say that of all the motors now in use for propelling horseless carriages

there is not one that gives complete satisfaction or is perfectly adapted to the purpose for which it is intended.

We will, however, describe them, as also the vehicles which they propel; but it is a work that must soon be re-written, for there is no doubt that in four or five years, or perhaps earlier, almost all the hydro-carburet cars now in use will have disappeared, and will have been replaced by others better suited to the object in view, both as regards the motors, the motion, and the general design.

The present state of auto-locomotion may be compared to an interesting game, played by several players, two very good ones, viz. Steam and Petroleum, and others less formidable, such as Electricity, Compressed Air, etc. Others are pressing forward for places round the green cloth: Liquid Carbonic Acid, and Acetylene, the last-comer, but not the least likely to break the bank.

At present, petroleum is winning easily, but this is because the chances of the game have been especially favourable to it, or rather because the rules of the game have been badly drawn up.

In short, all sorts of machines, never made to compete with one another, and to which it is impossible to apply one common set of rules, are submitted to a common test on equal terms.

Should we ever dream of starting in the same race English or Arab thoroughbreds with hacks, cart-horses, and cab-horses?

Let each fulfil its own destiny; some are formed

for speed, others for endurance and for drawing heavy loads.

Petroleum would seem at first sight to hold the record for speed, and it possesses all the qualities that could be desired for the object in view.

I say petroleum, not the petroleum motor, for the latter is still in its infancy, and therefore very imperfect. Hence steam maintains the advantages which are due to the researches of savants and engineers who long since invented the appliances and the mechanical devices without which motor-car traffic on public roads would be impossible.

Such benefactors to the cause of auto-locomotion as Papin, Cugnot, Watt, Pecqueur, Gurney, Hancock,[1] Séguier, Thomson,[2] Bollée,[3] Serpollet, and others, are entitled to our eternal gratitude.

Steam owes its present position mainly to the instantaneous evaporation generator invented by Serpollet in 1887.

Thanks to this boiler, which is of minimum volume and weight for a maximum power, the carriage-motor, with its boiler, occupies a very limited space, so that a force of 25 to 40 H.P. is obtained without the motor being too cumbersome. The steam-car thus equipped is suitable for

[1] Gurney and Hancock invented the circulating boilers and the boilers with elements, in 1825 and 1827.

[2] Thomson invented pneumatic tyres in 1845. (See vol. i. p. 147.)

[3] Pecqueur invented the differential movement in 1826, Bollée the steering apparatus with independent pivots in 1873.

conveying from fifteen to thirty passengers and their luggage to railway-stations or steam-boats, as also for express service.

The petroleum car, on the other hand, will be most used for the family carriage, containing from four to six seats, being light, quick, and elegant.

Steam is suitable for the omnibus hitherto drawn by three strong horses, or the delivery-van of the wholesale grocer, milkman, wine-merchant, laundress, etc.

Petroleum is suggested for the smart victoria and landau, with their high-stepping steeds.

But if, at present, we do not make petroleum cars of over 12 H.P., if these motors are invariable in their efficiency, inelastic, and incapable of lending themselves to sudden variations in the power required, we may be sure that later on, possibly in the near future, they will acquire the qualities they now lack.

And when the power of the petroleum motor can be made to vary at will like a good steam-engine, the expansion of which can be varied by the governor, it will be well able to hold its own. And perhaps the time is not far distant.

With regard to Compressed Air and Electricity, especially the latter, there is little to say at their present stage of development. The electric auto-car is only possible with accumulators, and owing to their dead weight, on the one hand, and to the necessity for frequent renewals on the other, this solution is not a very practical one.

The praiseworthy attempt of M. Jeanteaud in

the Paris-Bordeaux race, while it testified to his inexhaustible energy, showed that that of his motor was insufficient.

Liquid carbonic acid, allowing that the works must be visited occasionally, is at present far preferable to the electric accumulator. The steel bottles now sold like ordinary syphons, and which are scarcely any more liable to explosions than syphons themselves, are incalculable sources of energy. I cannot understand why they are not turned to better account.

The last entry, Acetylene, yesterday a scientific curiosity, to-day a commercial product, thanks to M. Henri Moissan's splendid discoveries, seems marvellously adapted to solve the problem of auto-locomotion.

When we calculate that 1 lb. of carburet of calcium only requires 9 oz. of water for its complete decomposition, and that this gives 34 gallons of acetylene representing a source of energy two and a half times as great as that of lighting-gas, we see that with 22 lbs. of this substance we can maintain a motor of one H.P. during ten hours.

As regards absence of dead weight, petroleum can alone compete with this wonderful product, and it will always possess the additional advantage of being obtainable in the most retired localities, where it is sold by all general dealers like the common necessaries of life.

Of course, lighting-gas must be classed with petroleum and acetylene, inasmuch as it is a

common product capable of working motors by direct combustion.

The number of hydro-carburets, capable of forming combustible compounds for practical purposes, is thus brought to three, and it would therefore have been more accurate to write this volume under the title of—

Hydro-Carburet Cars; but as this title is somewhat pedantic, it would certainly not have been so easily understood as that of **Petroleum Cars.**

Moreover petroleum cars are at present the only hydro-carburet cars that have been submitted to definite practical tests; they have come to stay, notwithstanding the urgent need that there is for their improvement; hence we cannot altogether reject this title. Besides, it possesses the advantage of localizing the attention of the public and the work of the writer, which is not an unimportant advantage when we consider that auto-locomotion being the rage, and petroleum cars being the most widely used of all motor-cars, every one is ready to put pen to paper in their honour without taking the trouble to study the question. It is important therefore that we should restrict ourselves within well-defined limits, enabling us to refute, once for all, the fantastic assertions whose results are disastrous both to the reading public and to the writers who insert them in newspapers and books.

If we assume, in fact, that out of one hundred readers, ninety-eight are ignorant of the subject, there still remain two in whose eyes the writer is

lowered. As to the other ninety-eight, the journal or book they purchase deceives them as to the quality of the goods sold by placing before them more or less apocryphal descriptions and explanations, instead of the actual truths to which they are entitled.

CHAPTER II

MOTOR-CAR RACES

MOTOR-CAR races were just what were wanted in order to give the public an idea of the importance of this new mode of transport, and of the place they are destined to occupy in the world's history, at the same time they have revealed the somewhat rudimentary state of an industry whose general methods are rather empirical, and somewhat dependent on chance.

The proprietors of the *Petit Journal* were the first to realize that a horseless carriage race, over a course of sufficient length, would excite public curiosity to the highest degree, and would at the same time run up the already enormous circulation of the *Journal*.

The *Petit Journal* was once more the enthusiastic apostle of progress, repeating for the motor-car what it had already done for the bicycle.

The Paris-Rouen Race.—The regulations drawn up by the *Petit Journal* were not arranged exactly for a race, but for a competition of horseless carriages to take place on July 22, 1894.

From the 19th to the 22nd there were prelimin-

ary test races of 31 miles on five roads radiating from Paris; the minimum speed to qualify for the great contest being 7¾ miles an hour.

Out of one hundred and two entries, only twenty-one were left in after these preliminary trials: fourteen petroleum and seven steam-cars.

The run from Paris and Rouen, seventy-eight miles, was satisfactorily completed by all the fourteen petroleum cars and by three only of the steam-cars.

The first prize was divided between two firms—Panhard and Levassor and Les Fils de Peugeot Frères; five other prizes were awarded to Messrs. de Dion, le Blant, le Brun, Vacheron and Roger.

The programme was not unduly exacting, prizes being offered to those horseless carriages that fulfilled the conditions of safety, ease in manipulation, and economy in consumption while on the road.

No return, however, was made with regard to this last condition, although it was one of great importance. It was simply stated that the cars that took the first three prizes, travelled at an average speed of 10½ miles per hour without taking into account the ratio between the weight propelled and the propelling power used; now this latter, which did not exceed 4 H.P. for the petroleum motors, was as much as 20 H.P. in de Dion's traction car (Tracteur de Dion).

No one, however, expressed dissatisfaction, and makers themselves were influenced by the success of this last apparatus, which rose at once into

favour to such an extent that makers who had competed with genuine "auto-mobiles" very well designed, abandoned them in favour of traction cars; among these were M. Le Blant and M. Scotte.

Uncertainty is, with rare exceptions, the lot of most inventors of auto-mobile systems, this being due as much to the want of reliability in their calculations as to the incompleteness of their methods.

Some who at first successfully constructed petroleum carriages, were hindered by the insufficiency of the hydro-carburet motive units; two, three, and four of these units have to be grouped together, and the process is somewhat complicated. Others, on the contrary, who at first were in favour of steam-carriages, seemed to be going over to petroleum.

Each one chooses his own course and then hesitates, because he finds the road branches out into two or even three directions: the results of the second race, from Paris to Bordeaux and back showed this pretty plainly.

Race from Paris to Bordeaux and back.—The organizers of this remarkable competition had certainly felt this: but they did not or would not notice this double tendency except by article five of their rules: the first prize can only be adjudged to a carriage made to seat four or more persons.

It seems, in fact, that this rule was intended to favour vehicles capable of carrying a certain number of passengers, and therefore likely to be of

more service than a simple carriage for two persons only.

But this distinction should have been more sharply defined: if it were so desirable to have a fair competition between steam and petroleum, the programme should have plainly stated what was required of each competitor.

The regulations, however, contained no less than forty-one articles, not one of which in any way touched the question of calculating the power expended.

At the start for Bordeaux, as in the Paris-Rouen race, there were twenty-one carriages: fourteen petroleum, six steam, and one electric. Only nine did the distance in the appointed time, and these shared the prizes: three being awarded to Panhard and Levassor, three to Les Fils de Peugeot Frères, two to M. Roger, and one to M. Amédée Bollée.

The results of this race, remarkable as it was, are of little value owing to the absence of all measurements. We notice moreover certain regrettable anomalies: the first arrival, who was eleven hours in advance of the second, could only take second prize because he carried two passengers only, being thus below the limit laid down in rule five, which, however, was only barely complied with by his fortunate rival. The condition of the roads plays a too important part in a trial where speed alone is taken into consideration; and in July last it was so absolutely unfavourable to steam that had it not been for Bollée's omnibus, it would have been ignominiously defeated.

Its honour was saved, however, thanks to the "Nouvelle," built sixteen years ago, and which would probably have been first had not the Fates then exhausted all their efforts against steam.

The "Tracteurs," brought into notice by the Paris-Rouen race, fell back, after the Paris-Bordeaux contest, into the obscurity from which they never ought to have emerged: M. de Dion himself gave up the idea of exhibiting them at the third Cycle Exhibition (December 1895).

We are thus compelled to admit that when this famous trial was over and done with we were no further advanced than before.

The Tunbridge Wells Competition, organized in London by Sir David Salomons, held on October 15, 1895, on the somewhat limited track (546 yards) belonging to the Agricultural Society, was rather a kind of parade or panoramic exhibition than a real comparative test, and no conclusions can be drawn from it.

The Race from Chicago to Waukegan and back was held under the auspices of the *Times Herald* on November 2, 1895, under conditions so exceptionally unfavourable that it had to be repeated on the 28th of the same month; if the conditions were not then much better, the competitors were at least sufficiently numerous to offer some elements of comparison.

The jury had to take into account economy of transport, the average cost per mile, and the power required for the different speeds.

These observations were corroborated by ana-

lytical tests conducted by Messrs. Barrett, Lundie and Summers, and their report was published in the *Times Herald* last April. We will give it later on, when our readers will have perused the descriptions of various systems.

The Race from Paris to Marseilles and back, held in September 1896, came off under regulations which did not differ from those of the Paris-Bordeaux race. It had been organized under the auspices of the Auto-mobile Club of France, and was certainly very interesting, but it could present no other element of comparison than the order of arrival.

The race arranged by the *Engineer*, to be run in England, in the autumn of that year, over a course of two hundred miles, was held subject to rules somewhat more searching, four categories of vehicles being distinguished:—

(*A*) Motor-car for four or more passengers, not weighing, when in working order, more than two tons, a prize of 9275 francs.[1]

(*B*) Carriage for two or three persons, not weighing, when in working order, more than one ton, a prize of 6625 francs.

(*C*) Carriage for conveying one ton of goods, not weighing, when loaded, more than two tons, a prize of 6625 francs.

(*D*) Car for conveying five cwt. of goods, not weighing, when loaded, more than one ton, a prize of 3350 francs.

[1] Calculated on the basis of 25 francs to the £, these four sums work out respectively at £371, £266, £266, and £134, but the figures do not look right.—A. B.

For these four classes of vehicles, the hydrocarburet motors were to consume petroleum of a density above 800.

Supplementary Prize.—For all vehicles for passengers or goods, propelled by a motor worked by spirit or gasoline of a density equal to or less than 700, a supplementary prize of 2225 francs was offered.

It does not appear, however, that the jury had any control whatever over the proceedings. Short trial trips were permissible on selected vehicles, if they were thought necessary, with a view to determining the consumption of those vehicles in proportion to their weight.

These races have produced a considerable effect, notwithstanding the defects we have mentioned in the regulations, which are due exclusively to the organizers of the two competitions from Paris to Rouen and Paris to Bordeaux, and the horseless carriage is now generally accepted, and has enthusiastic admirers.

FUTURE TRIALS ought therefore to be controlled by regulations that take more strictly into account the various elements of the problem, and it is urgently necessary that they should cease to be mere time races, in which the sole object is to secure first place, at any cost, and should develop into methodical and rational competitions. What we want is, to derive from them information that will lead us to judge clearly of the respective merits of the various vehicles taking part in them.

The object of this volume, upon which we are now entering, after these two preliminary chapters, is to enlighten readers, as far as lies in our power, as to the construction of motor-cars, generally of moderate weight, driven by motors, worked by liquid or gaseous hydro-carburets.

CHAPTER III

DIRECT COMBUSTION ENGINES

COMBUSTION ENGINES (*Machines à feu*).—Steam-engines were originally so called in France. The title might still be applied to all engines generating motive power by the combustion of carburetted substances with the aid of atmospheric oxygen, provided that they are divided into two distinct classes :—

(1) Steam Engines, in which the heat developed by the fuel is used to convert water or other liquids into steam, the pressure or the active force of which generates the motive energy, by its action in a special receiver.

(2) Direct Combustion Engines, in which the products of combustion act directly, by their expansion, in a receiver suitably arranged for retaining the energy and giving it off.

Hot-air Engines constitute a third solution of the problem, differing materially from the second, and yet resembling it in certain cases. We will revert to these later on.

Direct combustion engines also constitute two distinct classes :—

(1) Slow combustion motors in which the combination of the elements of the fuel with the oxygen of the air is effected without shock, and continuously; their working is similar to that of steam-engines in which the expansion of an elastic fluid produces the movement of the piston in the cylinder in which the piston constitutes a sort of movable partition.

(2) Motors acting by explosion or detonating motors, in which the working consists in forming a certain compound with a hydro-carburet and air, which detonates on ignition, and causes a considerable gaseous expansion.

These detonating motors are themselves subdivided into two classes:—

(*a*) Motors detonating by expansion, in which the explosion takes place outside the motive cylinder, and has the effect of feeding a reservoir of heated gases under pressure which, on being admitted into a cylinder, force the piston as they expand, or turn a kind of turbine or other similar receiver.

(*b*) Motors detonating by direct action.—In these the explosion which has taken place in the cylinder or in a chamber communicating with it, acts directly on the piston by the instantaneous gaseous expansion. These must also be classified according to the cycle of their operations.

(b^1) Duplex cycle: the piston draws in the detonating compound, and the explosion takes place as soon as the necessary quantum is obtained; the piston is then driven forward; it then returns, and

so on successively. These motors may be either simplex or duplex, with or without previous compression, but the compression does not take place in the same cylindrical capacity in which the explosion takes place.

(b^2) Quadruplex cycle: the compression takes place in the same capacity as the explosion—

1st period: the drawing in of the compound which detonates when the cylinder is full.

2nd period: the return of the piston, the compression of the compound, then the ignition.

3rd period: the explosion which impels the piston.

4th period: the return of the piston owing to the active force of the fly-wheel, and the expulsion of the burnt gases. In quadruple cycle motors there is always previous compression.

The motion of direct action detonating motors is the direct result of a series of shocks, the succession of which produces the movement.

They have been justly compared to whipping-tops, which children keep spinning by means of a series of uninterrupted tangential blows with the whip.

The direct action detonating motors are by far the oldest known: the cannon, in fact, is nothing but an exploding engine in which the expansive force of the gases acts directly on the ball to drive it as far as possible; and the Chinese, who seem to have invented everything, appear to have had cannon as early as the tenth century.

The Abbé Jean Hautefeuille, a native of Orleans, in 1678 published a pamphlet entitled *The Per-*

petual Pendulum, and how to Raise Water by Means of Gunpowder. In it he describes a kind of regulated cannon, in which explosions considerably attenuated and regulated, might be employed to raise water without the aid of a piston, as in the steam appliances at present in use called Pulsators or Pulsometers.

Huygens, who was himself the inventor of the atmospheric piston-engine, took up the Abbé Hautefeuille's idea and improved it. His invention is described in a report included in the publication issued in 1680, of various mathematical and physical papers by members of the Académie des Sciences under the title of *A New Motive-power Acting by Means of Gunpowder and Air.* Fig. 1 shows the arrangement we propose to follow in the words of Huygens himself:—

"A metal cylinder (C) closed at the bottom is provided with a piston (D). To the bottom is fitted a screwed box (B); in it is placed a little gunpowder, and it is then well screwed up.

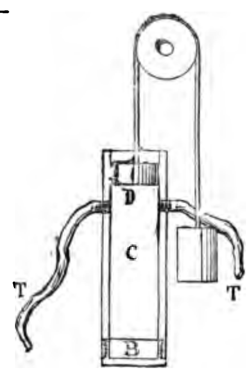


FIG. 1.

"The powder becoming ignited, immediately fills the cylinder with flame and drives out the air through leather tubes (T), which expand and are immediately closed by the outside air, so that the cylinder becomes a vacuum, or nearly so. Then

this piston is driven down by the pressure of the air weighing on it."

Here then we have a genuine complete engine; but next came Papin, who rejected gunpowder in favour of steam expansion; the steam-engine becomes a fact, and the explosion-engine retires for some time into oblivion. On October 31, 1791, John Barber took out a patent for a motor which was very badly described: it was atmospheric, and the piston in it was raised by the combustion of a compound of air and carburetted gases, ignited in a lateral receiver.

"It seems," says M. Aimé Witz, "that this was the first idea of the Continuous Combustion Engines which have lately come into favour."

Robert Street invented the Liquid Hydrocarburet Motor on May 7, 1794; in fact, on that date he took out a patent for the production by means of liquid, air, fire, and flame, of a force of inflammable vapour, for driving engines and pumps.

Here again the working parts are still the same, the cylinder and piston of the atmospheric engine: the bottom of the cylinder is heated, and into it falls drop by drop paraffin, turpentine, or some similar liquid which can be easily reduced to vapour. The production of these vapours raises the piston; at the same time the air is drawn in, and the combustion of the vapour is at once produced, thereby generating a large volume of heated gases, the force of which continues to raise the piston.

This piston is provided with a rod which is connected directly with the piston of a pump: soon the gases produced by combustion are cooled and condensed; this is effected easily because water-steam plays a considerable part in the process, and the piston recedes and draws in the water which will be driven out again by the next drive caused by the heated gases.

These two inventors therefore suggest Slow Combustion Motors, in which the elastic force of the burnt gases acts by continuous pressure on the piston.

Is not this like Éricsson's Hot Air Engine?

Not altogether, at least not as regards the kind of hot gases acting.

Éricsson's Hot Air Engine was in fact an apparatus so arranged that the products of combustion did not penetrate into the motive cylinder. I may be permitted to state, by the way, that Éricsson was not the inventor of the engines which have been called after him with about as much reason as America is called after Americ Vespuce, who never landed there till long after Christopher Columbus had discovered that continent.

As early as 1828 L. Franchot devoted himself to researches with the object of producing motive force by means of air expanded by heat; and even if we only accept the year 1836 as the authentic date of the publication of the designs and description of his hot air engine, we see that he was considerably in advance of Éricsson, whose invention is dated 1850.

But Franchot is not the only Frenchman who has studied this interesting question.

Liais in 1846, Lemoine in 1847, Lobereau in 1849, all designed hot air engines in which we find all the working parts that are reproduced in the Swedish engineer's engine. Lobereau's hot air engine, in particular, worked to perfection; and we think we are justified in saying that the real cause of the celebrity that attaches to the name of Ericsson lies in the good fortune that he had in meeting capitalists who placed him in a position to construct engines of great power, which, however, never realized the brilliant hopes aroused by his early efforts.

Hot air engines, moreover, no matter what system, do not ever seem to have been employed for the propulsion of auto-cars on account of their bulk and weight, which are always considerable in comparison with the power produced.

Direct Combustion Engines fed by hydrocarburets, on the contrary, can easily be constructed of very small dimensions in comparison to the amount of energy produced; this is due to the fact that the products of combustion act immediately and directly on the piston, whereas, in hot air engines, the gaseous mass resulting from combustion acts by heating the motive air which penetrates into the cylinder. This, at least, is so in the generality of cases.

The hydro-carburets at present at our disposal for working motor-cars are: lighting-gas, petroleum,

and acetylene, the future importance of which can already be anticipated.

Again, lighting-gas is not well adapted for driving vehicles on ordinary roads, and if we refer to it, it is mainly from a theoretical and historical point of view.

CHAPTER IV

GAS AND GAS-ENGINES

LEBON D'HUMBERSIN was the first to devise practical methods of producing lighting-gas. As a result of his earlier researches he took out a first patent on September 11, 1796, for his new mode of distillation; that was the thirty-seventh patent issued in France after the patent law was enacted.

Before that time, and particularly in England, experiments had been made in extricating the gas from coal in retorts, and what was called "spirits of coal" were obtained, but, till the time of Lebon, these were no more than laboratory tests, and he was the first to construct practical industrial appliances for the purpose.

The distillation of wood was performed by Lebon in a closed brick furnace, and the products of this distillation escaped through a tube, which, according to the description written by the inventor himself, "was directed into a vat or trough filled with water, whence it expanded so as to form a large condensing receiver.

"When the fire was lighted the wood became carbonized in the closed kiln, and the fumes, on reaching the condenser, there deposited the pitch and the pyroligneous acid; the gas liberated at the mouth of the condenser gave a light sufficiently bright and pure to warrant the hope of complete success."

The Thermo-Lamp.—Such was the name given by Lebon to his apparatus. It was destined to produce not only the raw material for lighting purposes, but also for heating, and by way of supplement, for motive power.

His invention, which was destined subsequently to undergo such considerable developments and to come into general use, did not remain unnoticed by the most distinguished savants of that period, particularly by Prony and Fourcroy.

Lebon's second patent was applied for on September 20, 1799, for "New methods of employing fuel more usefully, either for heating or for lighting purposes, and for collecting the various products thereof."

Two years afterwards, August 25, 1801, Lebon took out an addition to his patent, the object of which was "The construction of engines moved by the expansive force of gases, applicable to various industrial purposes, and to the direction of balloons."

Lebon was even the first to indicate the principle of compression, which he had produced in distinct cylinders before the entrance of the detonating compound in the motive cylinder, in accordance

with the arrangement shown in Fig. 2, indicated in the said patent.[1]

In a cylindrical receiver (*c*) the combustion is effected of the inflammable gas which is introduced into it through the pipe *b*, whilst the atmospheric air required for the compound is driven out through the pipe *a*.

The motive cylinder (C) has a double action,

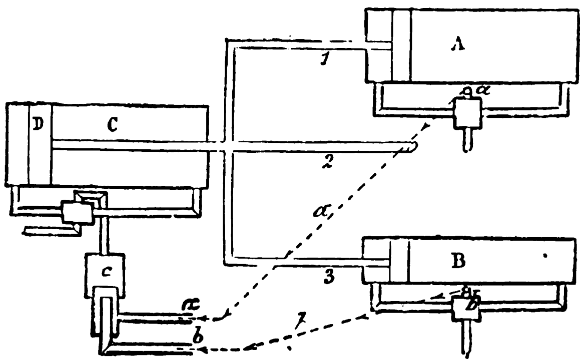


FIG. 2.—Lebon's Motor. (G. R.)

and receives sometimes on one surface of the piston and sometimes on the other, the effect of the expansion of the gases burnt at *c*.

The rod of this piston (D) branches out on leaving the cylinder into three rods sufficiently distant from one another to work:—

[1] This figure is borrowed from the excellent work of our colleague and friend, M. Gustave Richard: *The New Gas and Petroleum Motors* (Dunod et Vicq, Quai des Grands-Augustins, Paris). It is marked G. R., as will be all the other figures borrowed from the same writer.

(1) The piston of an atmospheric air-pump with double action (A), which sends the compressed air to *c*.

(2) The system of the transmission of movement to be utilized for performing some independent work.

(3) The piston of a duplex pump (B), for conveying into the receiver (C) the inflammable gas under pressure.

For lighting the mixture at *c*, Lebon suggests the employment of an electrical apparatus.

Lebon died the victim of a kind of fatality that seems to pitilessly pursue all our great inventors.

Papin, exiled by the revocation of the Edict of Nantes, dragged out a painful existence abroad, and died of want and grief.

Cugnot's first endeavours were already crowned with comparative success, when his labours were suddenly cut short by the Revolution.

Lebon d'Humbersin, who escaped from the terrors of that period, was murdered, at the age of thirty-seven, at the very moment when he was stepping into fame and fortune.

On December 3, the day after the coronation of Napoleon the First, for the festivities attending which event he had come to Paris, as chief engineer of roads and bridges, Lebon was found dying, stabbed in several places, in a thicket in the Champs-Elysées, which locality was then a complete wilderness, and more dangerous than the forest of Bondy.

The death of Lebon naturally put an end to the

progress of his invention, which was afterwards developed in England.

It is not our intention, however, to write here the entire history of the invention of gas-engines: it is not our custom to do over again work, which, in our opinion, has been very well done by others, and still less to appropriate their writings.

We therefore refer our readers for the history, as well as for the classification, theory, and general construction of gas-engines to the excellent theoretical and practical treatise on gas-engines, by our colleague, Aimé Witz.[1] Nevertheless, in the course of this work we propose giving some of the details of construction of certain motors which are specially applicable to the vehicles we are describing, and which were for the most part invented after the publication of the works to which we have referred.

Is Locomotion on ordinary roads by means of Gas-motors possible and practicable?—This is really the question with which we are dealing. Gas-engines as applied to the propulsion of the horseless carriage will always be attended by the same disadvantage as electricity, viz. the necessity of being dependent on charging stations. Compressed gas, a considerable store of which can be placed in the vehicle, has somewhat lessened this difficulty, and various attempts have been made in this direction. A tramway line was opened at the end of 1894 at Dessau (capital of the duchy of Anhalt, Germany),

[1] First Edition, 1886, 18mo; Bernard et Cie. Third Edition, revised and considerably enlarged, large 8vo; Bernard et Cie., 53ter Quai des Augustins, Paris.

the cars of which are provided with exploding motors supplied from reservoirs of gas compressed at 88 lbs. per square inch by the Luhrig System, the only practical one, and which has also been tried at Blackpool and Dresden. The Parisian Gas Company have also made some experiments with gas compressed under low pressure (86 to 114 lbs. per square inch), but these were not satisfactory.

With such low pressures we certainly need have little fear of explosion, and the expansion apparatus is very simple; but the same cannot be said of the boat named *L'Idée*, constructed by the Société de Navigation Fluviale, for the Seine service, from Hâvre to Paris: the gas in this case is in steel plate reservoirs, under a pressure of 1470 to 2200 lbs. per square inch.

Besides the risk attending the presence of these reservoirs on board a ship (or in a car), this system is evidently not one to be recommended. It compels us to be in communication with a station where the production of the gas requires a special plant; then it necessitates a system of conduits and connections, etc. At each operation, special arrangements must be made for cooling the reservoirs heated by the process of compression; a counter-system will of course be required, consisting of an expanding apparatus, for admitting the gas into the motors, and of arrangements for preventing the cooling resulting from the expansion.

The gas-engine cannot therefore supply a satisfactory solution of the problem of working auto-

mobiles, and we cannot understand how it can still be recommended in the presence of petroleum, which is really nothing but carburetted gas compressed to liquefaction.

If we consider in fact that we now obtain, in petroleum motors (which, however, still leave much to be desired), 2 H.P. per litre (about 2 pints) of petroleum, we can understand that this liquid hydro-carburet represents lighting-gas compressed at 1500 or 2000 atmospheres (10 or 13 tons per square inch), a result which, it is scarcely necessary to remark, will never be approached by the mechanical compression of lighting-gas.

CHAPTER V

PETROLEUM AND PETROLEUM MOTORS

PETROLEUM or naphtha oil seems to have been known and used in prehistoric times.

The Egyptians used naphtha and bitumen from time immemorial; the latter they used in preparing their mummies.

The Ethiopians rubbed their bodies with naphtha oil, and thought that they owed their robust health and their bodily vigour to this practice.

In the peninsula of Apcheron, the use of petroleum dates from the very earliest periods: six centuries before our era the fire-worshippers, the disciples of Zoroaster, lived there. They built temples where thousands of pilgrims came to worship and to bring their offerings. The city of Sarachane, situated not far from the modern Baku, had thus acquired considerable importance.

About the sixth century of the Christian era, the Arabs forced the Persians to renounce their own religion in favour of Islamism, and destroyed the temples where the gases issuing from the holy earth burnt day and night. Soon afterwards, the

disciples of Zoroaster, who had escaped death, returned to Apcheron and restored the temples.

Herodotus tells us that naphtha also appeared in other places: he mentions (fifth century before Christ) a well in the island of Zacynthus (Zante, one of the Ionian isles), which yielded a mixture of bitumen, salt-water and oil, on the surface of which, when poured into vessels, floated a blackish oil with an unpleasant smell.

Aristotle (fourth century before Christ) describes the bitumen deposits in Albania.

Strabo, Pliny, and Plutarch (first and second century of our era) wrote on the same subject.

Dioscorides (first century of our era) mentions the oil of Agrigentum, which under the name of oil of Sicily was used for lighting purposes, and was also known at Miano in Italy.

In India, China, and Japan there are also very well-known deposits of naphtha oil; those in the neighbourhood of Rangoon in India have long been famous.

The uses of petroleum were by no means numerous in those days; in the sixth century the Byzantine monks used it as one of the ingredients in making Greek fire, but with a few rare exceptions it was not employed for lighting purposes.

As early as the thirteenth century, Baku was an important commercial centre supplying petroleum oil to various parts of Asia, and among others to Bagdad. The importance of this trade is clearly shown by the continual wars waged between the

kings of Persia and Armenia for the possession of Baku.

Peter the Great, in his turn, seized the town, but it was re-taken from him by Nadir-Shah (1702), and its final annexation by Russia did not take place until a century later (1801).

The Dutch were working Indian oil-springs in 1750, and subsequently in 1771 springs were discovered in Galicia; the output was at first very limited, but it soon assumed large proportions.

In 1802 the city of Genoa was lighted by petroleum, and between 1825 and 1839 this industry was considerably developed not only in Galicia but also in Russia.

In 1849 there were 130 oil-wells at work in Baku, while in 1872 the number of wells sunk was 415.

The working of American petroleum springs is of much more recent date; it was not till May 1858 that Colonel Drake arrived in Titusville, which was then a very wretched agglomeration of wooden shanties. The first well, bored with the assistance of William Smith, yielded oil on August 28, 1859.

From that time wells multiplied at a prodigious rate, and a veritable stream of American oil began to flood the world.

Russia struggled to compete; in 1881 she succeeded in stopping the inflow of American oil, and in 1886 she herself exported two million tons.

The distillation of raw petroleum, for lighting purposes, which at first was carried out in a rudi-

mentary fashion, left a large proportion of residue, thin at the surface but black and viscous towards the bottom; this was known under the name of "Massout." The factories at Tchernogorod and Sarachane turned it out in such enormous quantities that it would have become a perfect drug had not Lentz, the engineer, found a means of utilizing it as fuel for boiler heating; all the boats navigating the Caspian Sea and the Volga now carry massout as fuel. This system of heating has also been adopted in Germany, where two battleships and four cruisers, now on the stocks, are fitted for burning this fuel. The German Government calculates, by means of this innovation, to effect a saving of 40 per cent. in the cost of fuel, and to reduce the staff of stokers, with the additional advantage of ease in manipulation and a saving in storage room for fuel.

At the present day, the viscous residues of petroleum distillation, as well as crude petroleum, and even lamp-oil, are in regular use for heating purposes in various industries. The solidification of petroleum, which has been so much discussed of late, may be unhesitatingly put down as an absurdity; the various attempts made to solidify petroleum—that is to say, to utilize it as a combustible, in the composition of patent fuel or briquettes for heating purposes, amount to nothing short of folly.

It is difficult to understand what advantage could be derived from denaturalizing a very rich combustible, the liquid state of which constitutes its most valuable property, since it is this which

renders its storage and distribution so supremely easy.

The first application of petroleum as propelling power for auto-cars was, in fact, in the form of fuel for generating steam in a boiler of a special type. The merit of this innovation is due to M. Pierre-Joseph Ravel, who on September 2, 1868, took out a patent for "A steam generator heated by mineral oils, applied to steam locomotion on ordinary roads, and to any other industrial purposes."

A handsome little Tilbury was built; the engine, and special boiler with rapid circulation, did not weigh more than 200 kilos. (4 cwts.) and developed 3 H.P.

But the time was not yet ripe for auto-locomotion, and later on the war supervened, which necessarily put an end to these premature attempts.

M. Ravel, moreover, soon became aware of the fact, that it is irrational to employ certain petroleum oils simply as a combustible, when they can be utilized direct in the engines by burning them under special conditions, in conjunction with carefully-gauged quantities of air. To-day he has thoroughly adopted this latter line of thought, and is now constructing motor-cars driven by oil-engines.

Petroleum-engines, in the same way as gas-engines, may be arranged with slow combustion, or with explosive action; they may utilize Gazolines, weighing from 625 to 660 grammes per litre (6¼ lbs. to 6 lbs. 10 oz. per gallon); light essences, 660 to 700 grammes (6 lbs. 10 oz. to 7 lbs.); heavy essences, 700 to 780 grammes (7 lbs. to 7 lbs. 13 oz.); light

oils, 780 to 820 grammes (7 lbs. 13 oz. to 8 lbs. 3 oz.); or heavy oils, 820 to 860 grammes (8 lbs. 3 oz. to 8 lbs. 9½ oz.).

At present a baneful tendency is in vogue towards the use of gazolines and essences, in preference to oils, for working engines with explosive action, and more especially those used for propelling vehicles.

It would be more rational in the case of engines to use exclusively lamp-oils, weighing from 780 to 820 grammes per litre (7 lbs. 13 oz. to 8 lbs. 3 oz. per gallon); these being the only ones which, thanks to the special care bestowed on their manufacture for lighting purposes, afford a guarantee of uniform composition and purity, properties absolutely indispensable when intended for use in lamps with ordinary wicks.

Gazolines and essences are much less carefully prepared, as they are simply the residues to which, when first working the oil-springs at Baku, so little value was attached that they were sometimes thrown into the sea.

But the utilization of heavy petroleum oils for the direct generation of motive power, is a problem which was solved twenty years ago, as the *Ready Motor*, patented in 1872 in the United States, by Brayton, has been acting satisfactorily since 1875, its consumption being 275 grammes (9¾ oz.) of oil per H.P. per hour.

The *Ready Motor*, however, was a "slow combustion" engine. The first motor with explosive action, consuming lamp-oil, was, we believe, the one

patented by Mr. Johannes Spiel in Germany, in 1886, and which figured at the Brussels Universal Exhibition in 1888.

This engineer appears to have been the first who practically realized how to treat liquid hydro-carburet, by injecting, with a small pump, the quantity of oil required for each explosion, but this principle had been already indicated in 1884 in a French patent, although carried out in another way.

At the Universal Exhibition of 1889, there were on show two explosion motors working with heavy petroleum, viz. that of M. Ragot and that of Messrs. Diedericks & Co.; they differed from the one just referred to inasmuch as instead of first drawing off, in the liquid state, and thereupon vaporizing the quantity of petroleum required for each explosion, they first reduced the oil to vapour in a small boiler, forming an integral part of the engine, and subsequently took from this store of vapour the proper quantity required for each explosion.

The Agricultural Syndicate of Meaux, when arranging, in May 1894, a competition of petroleum engines working with lamp-oil, received replies to their invitation from eleven makers, of whom only six completed the tests, viz. two Frenchmen, Merlin and Niel; two Englishmen, Griffin and Hornsby; one German named Grob; and a Swiss firm, viz. the "Société de Winterthur." All these motors acted satisfactorily; more especially that of Messrs. Merlin & Co., of Vierzon, which took first place.

Hence a heavy petroleum motor is an established fact; its action is perfect, and we can hardly conceive why the majority of motor-car makers should object to its use. It must be admitted, however, that some of them are gradually discarding their prejudices, and propose to present us shortly with vehicles propelled by lamp-oil.

CHAPTER VI

THE FIRST PETROLEUM CARS

Ravel's Car.—The first application of petroleum was for lighting, and the second for heating purposes. Its direct employment in motors did not come in until afterwards.

The first lamps used for burning petroleum were manufactured by the firms of Guillemont and Maris, of Paris, about 1855, being originally intended for burning schist oils; they were bought by Americans for petroleum-burning about 1858. They were lamps with flat wicks. Soon after, lamps with round wicks were brought out, and subsequently, oil-stoves with several flat or round wicks.

The first petroleum boilers were neither more nor less than large cauldrons, heated by huge stove lamps, and the first motor-car worked by means of a petroleum boiler was fitted with one of these cauldrons, a kind of improved tea-urn (*samovar*).

The reader may think that the vehicles driven by petroleum boilers might more appropriately come

under the heading of "Steam-Cars," but as it was necessary that their description should be preceded by a disquisition on petroleums, which would have been rather out of place in such a treatise, we have included them in this present work.

They will constitute a special feature in this volume, the title of which, after all, is quite applicable to them, as they are indeed "petroleum cars," in which the utilization of this hydro-carburet is carried out in a special manner.

Ravel's petroleum boiler is, as far as we know, the first ever constructed for driving a carriage, or at any rate it is the first creation of the kind, the existence of which is well established by trustworthy and irrefutable documents.

M. Ravel is certainly one of the pioneers of auto-locomotion—one of the first whom this problem attracted, and who found a simple and economical solution, at a time when gas-engines with explosive action being as yet scarcely known, inventors were studying to construct a motor-car with steam-engine and boilers.

It was on September 2, 1868, that M. Ravel filed the specification of his patent (No. 82,263) under the title: "Steam boiler heated by mineral oils, and applied to steam locomotion on ordinary roads, and for any other industrial uses." (Fig. 3.)

A boiler shell (A), of cylindro-spherical shape, and made of riveted plate, was fitted in its interior cavity with a coil (S), and completely surrounded on the outside by water held in a copper jacket in the space (*a*).

The heating apparatus consisted of a powerful petroleum lamp (P), fed by petroleum from *p*, and fitted with three concentric wicks, separated by interstices for the admission of air, which directed the flame into the interior of the coil (S), made up of closely packed coils forming a partition.

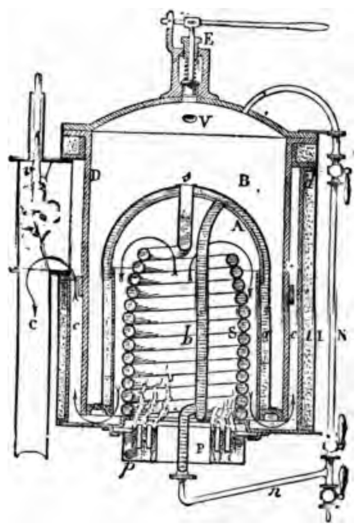


FIG. 3.—Ravel's Petroleum Boiler. (Fr. A.)

The combustion gases ascended the space enclosed by the coil (S), and the shell (A), passed into an external annular chamber (*c*), communicating with the chimney (C). In the drawing annexed to this specification, this chimney throws out the smoke at the top in the usual way, but in the car

which was constructed towards the end of the same year, 1868, the chimney was reversed, so as to discharge the products of combustion underneath and at the back of the car, the draught being constantly kept alive by the exhaust steam acting as a blast at *v*.[1]

A cylindrical casing of riveted plate, with a cover fitted with a safety-valve (E), formed a large steam-chamber (B) around the water-chamber (*a*); it was itself surrounded by an outer casing (*d*) forming the smoke-box (*c*), and protected outside by a layer of non-conducting material (*i*) encased in a polished brass wall (I). The steam intake was under the dome, at V.

The water, on being injected by a pump, first reached the lower part of chamber (*a*), filled this as well as the coil with water, the level of which was shown in the side tube (N), which communicated with the interior by *n*.

It is easy to see that this boiler is designed in strictest compliance with the rules of thermodynamics, the cold water being first brought into contact with cooled gases, then ascending into the space *a*, so as to gradually come in contact with more heated gases, and thereupon redescending through *b*, and finally arriving, already heated, at the bottom of the coil, it is submitted to the influence of the combustion gases. A brisk circulation ensues, up to the orifice (*s*) from which the

[1] M. Meyan, the courteous manager of the *France Automobile*, has kindly lent us this block; it is therefore marked Fr. A., as will be the case hereafter with all blocks borrowed from that journal.

steam escapes, while the feed is regulated by the action of the pump.

The "Ravel" Boiler, though belonging to the **Rapid Evaporation** type, avoids two faults which are generally found in this type of boiler. It contains, in *a*, a comparatively large volume of water at a rather low temperature, yet sufficient to precipitate the deposits; then, at B, there is a large supply of steam, which, being in contact with the hot partition (D), is dried and slightly superheated.

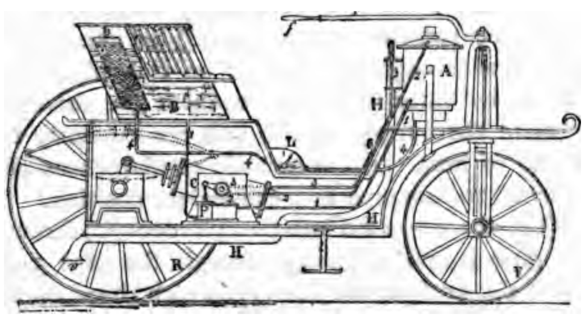


FIG. 4.—Ravel's Car, 1868. (Fr. A.)

A "Tilbury Tricycle" (Fig. 4) was made towards the end of 1868. The engine, with two oscillating cylinders, was made to act direct on the axle of the driving-wheels, its simplicity, strength and low speed (100 revolutions per minute) enabling it to withstand road travelling.

This is an arrangement which appears to us far preferable to the high-speed engines, which can only act on the driving-shaft by means of gearings, pinions, chains, etc., which, apart from their dead

weight, absorb from 40 to 60 per cent. of the actual motive power.

The boiler (A) as well as the steering-lever (*f*) of the front wheel (F) were placed in front of the driver. The cylinders (C) acted on the wheels (R) by means of a two-throw crank, and a pump (P), driven direct from the oscillating shaft of the cylinder (C), fed the boiler with cold water through the pipe (*l*), as it came from the tank (B) arranged under and at the back of the seat. Suspended within this tank and completely surrounded by water, the petroleum reservoir (D) fed the heating apparatus through the pipe 4; on this pipe there was an indicator (L), which enabled the driver to regulate the supply of oil, and consequently the degree of heat. An automatic regulator was also attached to this pipe in a convenient position.

The steam was fed into the cylinders (C) through the pipe 2, and escaping through the pipe 3, assisted the draft in the flue (H), which threw off the smoke at the rear at *v*, on to the road.

The boiler and engine, developing 3 H.P., weighed under 200 kilos. (4 cwt.), and the first trials were very successful. The engine, which presented the peculiar feature of being fed with steam at low pressure, yet very dry and slightly superheated, was a low-speed engine (100 revolutions per minute), and consequently could act directly on the driving-shaft; the bearing-springs of the car rested on the latter.

In these days of pneumatic tyres, this arrangement would be more appropriate than ever.

The *Auto-car*, an English periodical published in Coventry, described in its issue of April 4, 1896, a motor-car fitted with a petroleum-boiler, invented, it is said, by Joseph Wilkinson previous to M. Ravel's invention. Figs. 5 and 6 are taken from the sketches published in the English journal.

These Figs. 5 and 6 may suggest some curious reflections: the four wheels are phantoms, with direct spokes; now we believe—and this has not, up to the present, been disputed—that the inventor of this system was Louis Gonel, who patented it in 1867.

It may therefore come as a surprise that the year 1865 should be given as the time when this arrangement was designed.

The catalogue of English patents, which we have looked through very carefully from 1862 to 1868, gives some twenty Wilkinsons, distinguished as John, Thomas, William, Albert, George, and Edward, who have taken out patents of all sorts; such as weaving, spinning, rope-making, and grinding machinery, jewelry, pumps, fishing-tackle, horse-shoes, printers' type, etc., but not a single motor-car worked by a petroleum-boiler. There is only one John Wilkinson, and he patented a watch.

Probably Joseph Wilkinson was at the London Exhibition in 1862, and seeing there a steam-car made by one Lee of Leicester, conceived the idea of building a lighter car and using petroleum for heating his boiler.

The boiler is placed on one side at A, and consists of a vertical figure connected with a horizontal part, with a suspended flue (H). A double cylinder

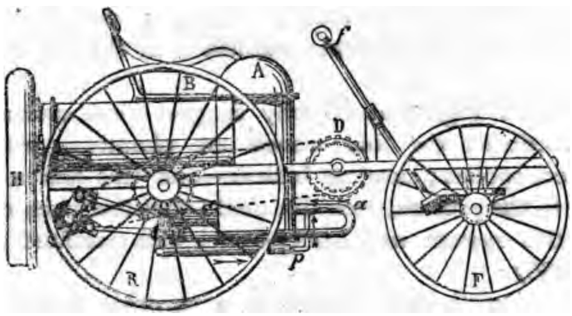


FIG. 5.—Wilkinson's Car, elevation. (Fr. A.)

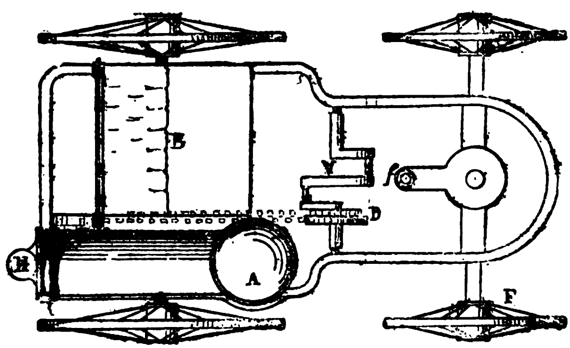


FIG. 6.—Wilkinson's Car, plan. (Fr. A.)

engine (C) acts on a double-crank shaft (V), to which is keyed a wheel (D), and this by means of a chain works the back driving-wheel (R); then as

the wheel (*d*) turns it acts on the air-pump (P), and the liquid fuel and the necessary air for combustion purposes are injected into the furnace through the oil-pipe (*p*) and the air-tube (*a*).

At B there is a seat for two persons, underneath which is stored the supply of oil and water. The front wheels (F) run loose on the axle, but owing to the pivoting arrangement thereto attached they can be steered with the lever (*f*), and the corresponding bevel gear.

According to the *Auto-car*, this design was finally worked out in 1865 by Joseph Wilkinson, who was at that time residing in Birmingham.

The English paper justly criticizes its unsymmetrical arrangement, which is far from presenting the harmonious grouping of the various parts which characterizes M. Ravel's car.

We much regret having been unable to discover any trace of this invention, for although the article in the *Auto-car* is certainly written in a very neat and interesting style, it lacks substantiation, and does not contain any argument in disproof of the reasons which induce us to attribute the priority in this invention to our countryman, M. Ravel.

We may also add that M. Ravel's efforts failed to attract as much attention as one might have expected; the time was not ripe for auto-locomotion, and the war soon after put an end to his experiments.

CHAPTER VII

THE NEW PETROLEUM BURNERS

THE SERPOLLET CAR

THE war of 1870 and the siege of Paris tended to stimulate researches into the methods by which petroleum could be utilized as a heating agent as applied to industrial purposes, for while Paris had run out of coals she had a large supply of petroleum.

The Wiesnegg Burner, specially invented for burning petroleum for heating purposes, was soon adopted in Paris factories, and its use was even more general in some of the baths and public laundries.

Yet it was the Russian and American engineers who took the lead in the practical development of petroleum as industrial fuel.

Lentz invented his Massout burner in 1876, and in so doing conferred a boon on the refiners of Baku, and in fact on the whole of Russia.

This substance, a syrup-like mixture of heavy residual oils, was an encumbrance in the factories at Tchernogorod and Sarachane, where, not knowing what to do with it, it was sold at the ridiculous price of about 5*d.* per cwt.

Thanks to this clever chemist, this residue could be used for heating boilers on steamships, and this was a great aid to navigation on the Caspian Sea and the Volga, for at that time the only available fuel was Saxaul wood or English coal, both very costly.[1]

The petroleum burners now known may be classed under two heads, Russian and American.

In both, the petroleum is mechanically fed by a strong jet of fluid under pressure; steam and air may be used indiscriminately and successfully. The choice depends on circumstances, yet steam is

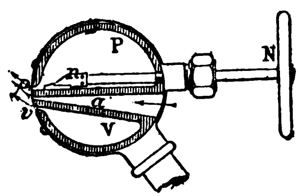


FIG. 7.—The Karapétoff Burner.

preferable, because it dispenses with air-reservoirs, compressors, etc.

It is rare that the use of air is desirable except in the case of steamers, and then it is in order to avoid a waste of fresh-water; in all other cases steam should be used for producing the petroleum spray, particularly as when projected against the red-hot bricks of the furnace with the hydrocarburet it undergoes a decomposition, the elements of which, viz. oxygen and hydrogen, still further stimulate combustion.

[1] *Le Pétrole et ses applications*, by Henry Deutsch: May et Motteroz, 7 Rue Saint-Benoît.

The Russian burners generally consist, like Karapétoff's (Fig. 7), of an atonizing or spray chamber; the petroleum being contained in a cylindrical reservoir, the shell of which is perforated with small holes.

The reservoir is divided into two compartments by a partition (*a*), placed on the same level as the two orifices (*v*) and (*p*).

As the steam reaches the compartment (V) at a suitable pressure, it forces a jet through the orifice (*v*), and this mechanically carries with it from the compartment (P), first the petroleum which it discharges through the orifice (*p*), and secondly the necessary air for combustion which is discharged through the orifice (*a*).

The flow of oil can be regulated by means of a hand-wheel (N), by which a slide (*n*) can be shifted along the central partition, so as to reduce the width of the aperture (*p*).

American burners are, generally speaking, very similar to ordinary injectors; they contain two concentric tubes, with slightly contracted ends, and through these the petroleum and steam, or air under pressure, respectively escape.

The Urquhart Burner (see Fig. 8) contains round orifices; it is used in America for heating the locomotives on the Central Pacific Railway, and might also be employed for heating light boilers for auto-cars.

The steam (V) is forced out through the central orifice (*v*), while the oil (P) flows out through the channel (*p*), at the end of which there is a nozzle,

This arrangement is far superior to the system on the inverse principle, because it ensures the free and unrestricted circulation of the petroleum through the circular nozzle, the orifice of which (*p*) can never get choked up.

The air required to maintain combustion is mechanically drawn in through the circular blast-pipe (*a*) leading into the combustion chamber (F), and surrounding the injector; the discharge from the latter is regulated by the position of the steam-

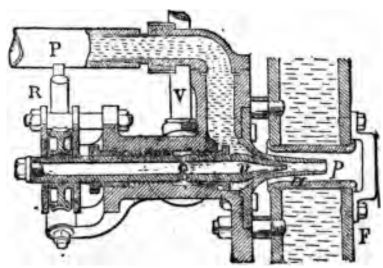


FIG. 8.—The "Urquhart" Petroleum Burner.

cone (*v*), which may be adjusted by R, so as to contract circular oil passage as required.

The Burton Burner (Fig. 9) is also much in use in the United States. In this, the steam is introduced from above at V, and the oil from below, through P, the pressure used being from 5 to $7\frac{1}{2}$ lbs.

The regulation of the oil-supply is effected by modifying the force of the steam-jet with the regulating screw (*v*); this screw causes a needle to enter and obstruct the steam-orifice. The oil issues

from a projecting nozzle (*p*), and the air enters, when required, through the orifices at *a* and *a'*. Fire-bars are dispensed with, and replaced by a bottom of fire-bricks, which may be hollow, or, if solid, are arranged with interstices at B, and a vertical partition (*b*) of similar bricks must be arranged at some little distance in front of the burner.

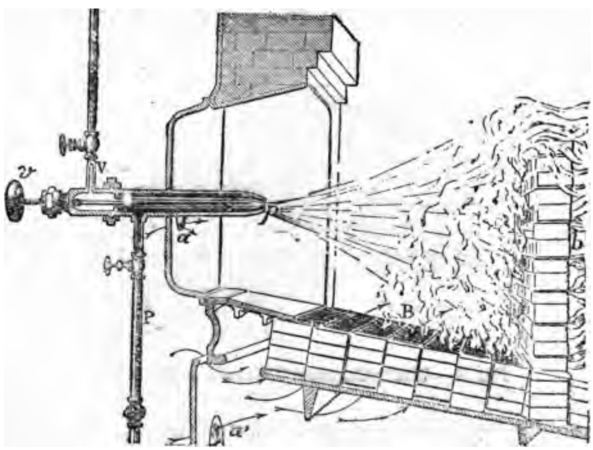


FIG. 9.—The "Burton" Petroleum Burner.

These bricks last longer than metallic partitions, and when brought to a white heat they will evaporate any globules of oil which may not have been converted into spray. They moreover serve to generate heat by preventing any cold air from striking the sides of the boiler, and in this way they obviate smoke.

From this the reader can easily form an idea of the petroleum boiler; it would be arranged behind the partition (*b*) absolutely in the same form, and with the same arrangement, according to its particular type, as if it were behind the fire-bridge of an ordinary furnace. The number of burners would be increased in proportion to the power and size of the boiler.[1]

"**Longuemare**" **Burners.**—The "Burton" system is particularly suitable for heating large stationary boilers, and we mention it as a curiosity, because it is the one that was used at the Chicago Universal Exhibition in 1893, for heating the fifty-two boilers whence the motive power was derived for the whole of the machinery (52,000 H.P.).

But we will now return to motor-cars, in which the consumption of steam cannot bear comparison with the consumption in this colossal machinery.

These must content themselves with burners of a more unpretentious and handier character, and the "Serpollet" boiler in particular, the only one we could dream of using in connection with motor-cars, could not, on account of its peculiar arrangements, accommodate itself to any of the burner systems to which we have referred.

In fact, M. Serpollet has no occasion to appeal to foreign invention, as he found among his own

[1] Figs. 7, 8, and 9 are taken from the excellent work by Messrs. Grille and Falconnet, entitled *The New Boilers at the Chicago Exhibition*, published by Mr. E. Bernard, 53ter Quai des Augustins, Paris.

countrymen, in Paris, a modest and indefatigable worker like himself, M. Longuemare, and between them they devised a petroleum burner for boilers, which gives them all they desire.

The Longuemare Burner for Refined Petroleum.—Taking it as granted that the ignition of the explosive compound in detonating motors, by means of an incandescent tube, is one of the most

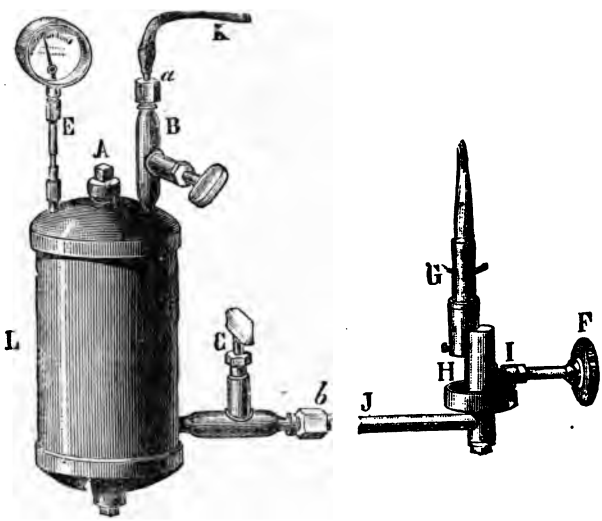


FIG. 10.—"Longuemare" Burner for Essence of Petroleum.

successful solutions of the problem, the mechanism being simplicity itself, we wanted, for the purpose of keeping the tube incandescent, a burner that would be simple, inextinguishable, economical, of small compass, and fed with the same hydro-

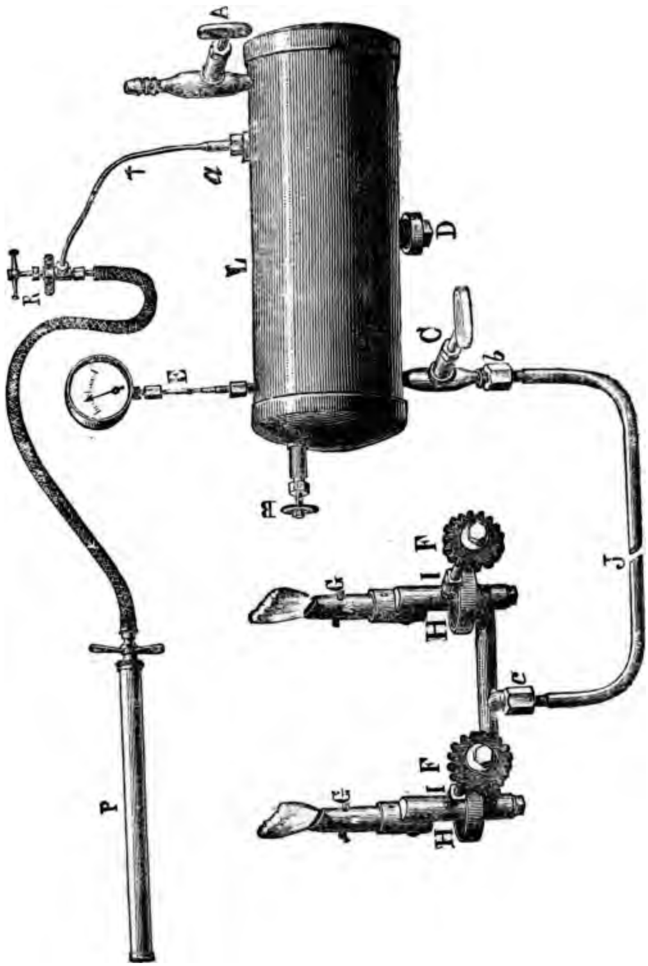


FIG. 11.—"Longuemare" Duplex Burner for Essence of Petroleum.

carburet that is used for making the explosive compound.

M. Longuemare's apparatus, which is shown in Fig. 10, completely meets these requirements, as does also the **Duplex Burner** given in Fig. 11, designed, on the same principle, for double cylinder engines. The same letters, in this illustration, indicate the same as in Fig. 10, viz.—

L, small reservoir for refined petroleum under pressure.

A, feed-stopper.

B, gauge-cock.

D, draining-plug.

C *b*, oil outlet.

J, oil inlets for each of the burners (F, I, G).

E, pressure-gauge.

H, cap for burning methylated spirits at the start.

a T, tube letting the compressed air into the reservoir (L).

P, air-pump. R, valve.

Fig. 12 shows the same burner with a different arrangement; the enlarged portion (S) contains a coil consisting of a brass tube of small diameter, in which the vaporization of the essence takes place more rapidly and more effectively than in the ordinary type, a section of which is given in Fig. 13.

The essence, after passing through (J), is first filtered through the metallic gauzes (*a*), and through an asbestos plug (A); at that very moment, the heat stored in the metallic walls sets up vaporiz-

ation, and this is completed during the passage through the narrow crank-pipe turned by the wormed rod, which can be screwed at will into the adjustment (T) by means of the set-screw (F). Hence what finds its way into the upper chamber, and feeds the orifice (*o*) at the top of the nozzle, is really vaporized essence: this is at once ignited, and the flame, as it is forced out of the nozzle (G) from the numerous air-holes, may be as much as 15 centimetres (6 in.) high.

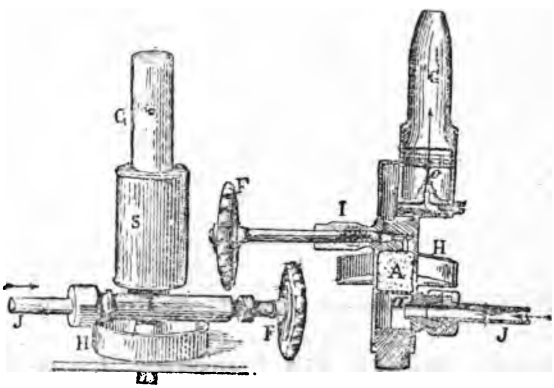


FIG. 12.—Small Burner with Coil. FIG. 13.—Section of Burner.

Burners for Lamp Petroleum, suitable for Boilers.—With the burner shown in Fig. 13 or in Fig. 12, very nearly the same results are obtained; but when using the latter and the coil (S), vaporization is more intense.

This intense vaporization is absolutely essential in the case of a burner for lamp petroleum adapted

for boiler heating, because the density of the fluid is from 800° to 820°, while the boiling heat is from 100° to 120° Fahr., whereas that of refined petroleum varies from 60° to 90° Fahr.

Fig. 14 gives a group of three of these intense-vaporization burners used in the preliminary tests of Serpollet's petroleum boiler: the petroleum comes in at (F), and the cups are used as before described for heating previous to ignition. The coil has been enlarged so that it runs round the entire inner surface of the sheet-iron cylinder which surrounds the actual burner, and the heat of the flame is communicated to it direct.

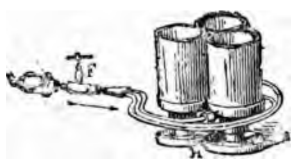


FIG. 14.—Petroleum Heating Apparatus with Three Burners.

Nevertheless, even this arrangement left something to be desired, and it was while making improvements in it that the one shown in Fig. 15 was produced, and this may be regarded as a definite type.

The burner properly so called consists mainly of a solid cross-piece of bronze (B), two branches of which are hollowed out; the oil after entering at J under a pressure which may vary from ½ to 5 kilogrammes per square centimetre (7 to 70 lbs.

per square inch), circulates through the coil (S), and returns through the conduit (*j*) to the burner.

The current of vapour formed in its passage through the coil heated by the flame of the apparatus; is broken up on the exterior of the cap (*c*), so that it throws off any foreign substances,

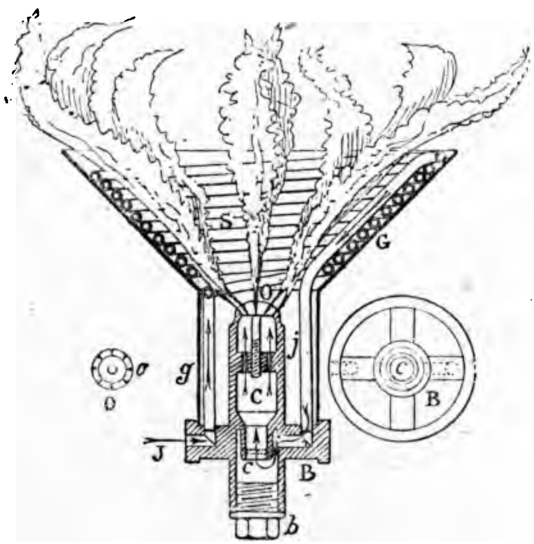


FIG. 15.—"Longuemare" Burner for Lamp Petroleum.

and these are eliminated by withdrawing the stopper (*b*). It then passes through some metallic gauzes (*c*) into the chamber (C), whence passing through eight holes in the top, it reaches the nozzle (O). This is formed by a small chamber, closed with a brass cone, on the circumference of

which eight very fine slots are cut, as shown at (*o*) (see plan of cone (O) to the left of the block). Through these eight slots the petroleum vapour escapes with a force in proportion to the pressure, and causes eight blue quivering flames, the length of which may be from 50 to 60 centimetres (20 to 24 in.), and which spread out above the iron-plate spreader cone (G). Another cylinder (*g*), also of iron-plate, forms a flue for drawing air through the cross-piece (B).

The intensity of the heat developed will be in proportion to the pressure in the reservoir, and this pressure stimulates the consumption and the rapidity with which the petroleum circulates in the coil (S). A single apparatus of this class furnishes quite enough motive power for one of Serpollet's steam tricycles.

The New "Serpollet" Car with Petroleum Boiler.—The first vehicle made by Serpollet, in which the "Longuemare" lamp-oil burner was used to heat a Serpollet boiler, was the tricycle shown in Fig. 16, with two wooden back-driving wheels (R), a safety steering wheel (F) in front, all three being fitted with pneumatic tyres.

A tubular steel frame (T) resting on the rear-axle is turned up in front in the form of a "swan's neck" (*t*), and supported on the front wheel by a strong spiral spring (*s*).

This half-suspended frame carries the machinery (C), viz. a couple of steam-cylinders placed side by side and cast in one piece; they work at a pressure of 15 atmospheres (220 lbs. per square

inch), and, by means of two cranks keyed at an angle of 90 degrees (to avoid dead points), they act on the pinion-shaft (*e*), which gears into the cog-wheel (E), keyed on to the axle of the wheels (R); this cog-wheel is fitted with a differential gear. As the shaft of *e* revolves at the rate of about 350 revolutions, the axle will make from 100 to 120 revolutions per minute.

At *p* we have the starting pump, worked by hand by means of a lever (*n*), then the ordinary working pump (*p*), the plunger of which is driven by an eccentric keyed to the axle.

The "Serpollet" boiler (A) with its coil, whose heating surface represents 1·50 (16 square feet), is heated by the burner G (Fig. 15) suspended underneath. The water-tank (B), of a capacity of 65 litres (14½ gallons), partly surrounds the boiler, and the combustion gases, mixed with the exhaust steam, pass off through the inverted flue (*a*) at the back. The exhaust is completely invisible, thanks to the slight overheating undergone by the steam outlet pipe at the upper part of the boiler (A).

The tank (B) and the boiler are supported by a frame (L), suspended at the back by springs (H), and by a transverse spring (*h*) in front. This frame, which forms the front-body of the car, carries a seat (S) for two persons, as well as two oil-tanks, viz. (D) to hold 20 litres (4½ gallons), and (*d*) a small distributing reservoir communicating with the burner (G), and in which the pressure is obtained by forcing the oil into it from (D) by means of a special pump.

The traveller seated at S commands the lever (*n*) of the pump (*p*), and the lever of the steering-wheel (*f*), as well as a treadle controlling the equilibrium-valve which regulates the supply of feed-water to the boiler; this valve regulates the speed.

The pressure-gauge (*m*) indicating the pressure in the small reservoir (*d*) with its air-escape cock, and the cock for regulating the oil-feed to the

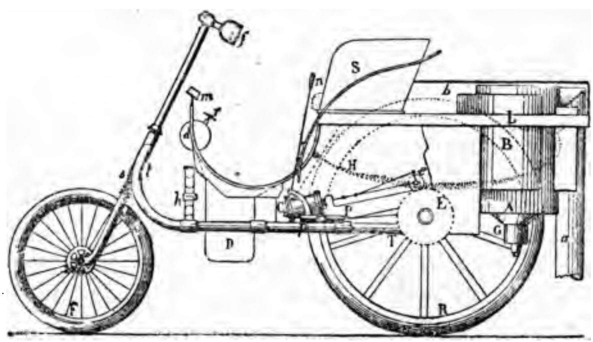


FIG. 19.—The New "Serpollet" Car.

burner (*r*), are all within view of the driver. Another cock, also adjustable at will, controls the communication between the two reservoirs (D and *d*). When this latter cock is opened, and then the one communicating with the open air, the cock (*d*) empties itself of oil and becomes filled with air; then the supply of oil under pressure may be replenished, by means of the special pump in the feed-reservoir (*d*).

The burner (G) consumes from 1 to 5 kilos. (2 to 11 lbs.) of petroleum per hour; the boiler, weighing about 50 kilos. (110 lbs.), is capable of evaporating 60 kilos. (132 lbs.) of water during the same period.

The cylinders (C) under normal conditions develop 4 H.P. per hour; they are effectually lubricated by an automatic oil-pump. The car is covered in with a sheet-iron cover (*b*), and can easily be inspected by raising this cover and turning forward the hinged seat (S). The machinery is also protected at the sides by sheet-iron panels.

With this vehicle (the clever and well-balanced arrangement of which furnishes another proof of the remarkable abilities of its inventor) M. Serpollet can attain a speed of 40 kilometres (25 miles) an hour up a gradient of 5 per 100, and of 12 kilometres per hour (7½ miles) up a gradient of 17 per 100. The total weight of the car when charged and carrying two passengers, is 400 kilos. (8 cwts.), and the noise of the exhaust, as well as the vibration, are reduced to nil.

CHAPTER VIII

MOTOR BICYCLES

OPINIONS are divided as to the utility and the future of "inanimate motor bicycles." As a matter of fact, the natural and most appropriate motor of the bicycle is the cyclist, whose activity in propelling the machine produces those hygienic results which are now admitted on all hands. On a self-propelling machine, the body, being motionless, is subject to severe chills, hence the rider must beware of pains in the knees and shoulders, neuralgia and the like.

Something may be said for compound cycling in which the rider may either sit motionless, allowing himself to be carried along at a terrific pace by the auto-motor, or may quietly pedal along, viewing the scenery as he goes; or again, he may on encountering a stiff hill join forces with the motor and climb the steep at his ease, provided of course that the bicycle is fitted with pedals.

The "Daimler" Safety Bicycle, however, which we believe is the oldest motor-cycle extant, was not designed with this view; the rider, seated in the saddle (S), is supposed to place his feet on the

fixed foot-rests (*s* and *s'*), and keep them motionless (Figs. 17 and 18).

The engine (BC), the reservoir for refined petroleum (D), and the carburator (*d*), are carried in a

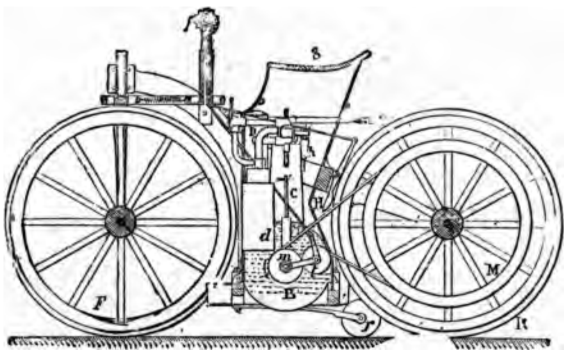


FIG. 17.—"Daimler" Bicycle (1885). G. R.)

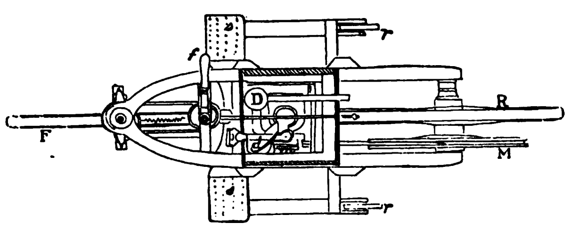


FIG. 18.—"Daimler" Bicycle (plan). (G. R.)

solid frame between the two wheels, thereby adding to the stability of the machine.

The engine acts direct, by means of a friction-coupling and a grooved pulley (*m*), which by means of a round driving-belt communicates its motion

to a larger pulley (M) keyed on to the axle of the driving-wheel (R). Thanks to a tension arrangement (*t*), the motion can be transmitted to this wheel at the driver's will: this arrangement is brought into action by turning the handle (*f*) of the steering apparatus on its own axis; the movement is similar to that adopted in the brakes of the first "Michaux" bicycles; in fact, in this case also, the movement of the handle-bar (*f*) controls the brake (H).

The front-wheel (F) serves as a steering-wheel, and is controlled by turning the handle-bar (*f*) on its vertical axis.

Two rollers (*r* and *r'*) serve to steady the machine sufficiently to enable the rider to mount after having started the engine. He now brings the tension arrangement (*t*) into play, so as to make the belt act on the large pulley (M), and he may now raise the steadying-rollers (*r*, *r'*).

This machine, constructed in 1885, with single cylinder, Daimler motor, and patented in the same year, is but little known. Although the results obtained were by no means bad, it was soon after discarded by its inventor, who devoted himself entirely to the construction of his two-cylinder motor, and to the study of its numerous applications.

But the **Millet Bicycle**, shown in Fig. 19,[1] does

[1] Fig. 19 is borrowed from *Locomotion Automobile*. The courteous manager and founder of this paper, M. Raoul Vuillemot, has kindly authorized us to reproduce it; it is marked L. A., as will also be the case hereafter with all blocks taken from the same paper.

come under the category in question ; it is a compound cycle, which can be worked by any inanimate motor or by the rider, or by both combined, as the treadles (*p*) are retained.

These may be worked in the usual way by the rider seated in the saddle (S) ; the two wheels are protected by mud-guards (B and *s*) ; and two supports (*bb*), which are raised while travelling, serve to steady it when at rest.

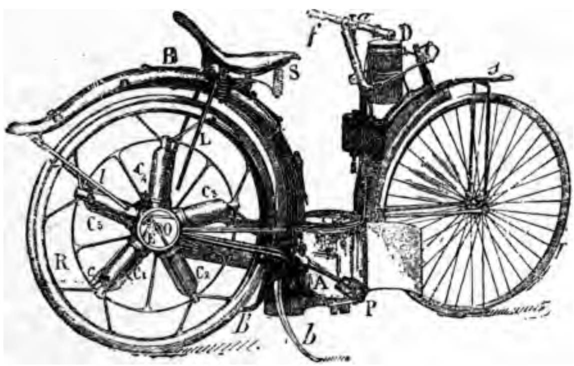


FIG. 19.—The "Millet" Bicycle. (L. A.)

Apart from this, M. Millet's vehicle is a novelty, owing to the peculiar manner in which the power is applied to the driving-wheel (R), which is held in place by the forks (L and *l*).

The engine cylinders, to the number of five (C_1, C_2, C_3, C_4, C_5), are arranged in the form of five spokes to the wheel (R), in which they are supported by an iron frame arranged with rigid triangular stays ; each of these cylinders repre-

sents an ordinary detonating motor cylinder, the action of which takes place in four stages in the usual way.

The detonating compound, prepared in a carburator situated below the mud-guard (B), which forms a reservoir for the refined petroleum, is fed to the top of each cylinder by the tubes (*c*), which branch off from a central box, the front cover of which is done away with; in this box a disc (E), which is not joined to the remaining parts, is fixed to the spindle (O), and on this rolls, on ball-bearings, the hollow nave to which the back cover of the box is fixed.

The five piston-rods are attached to the outer circumference of this disc (E), and in proportion as the explosions in the cylinders drive the five piston-rods forward, disc (E) being stationary, the cylinders are made to rotate round the axis (O), thus causing the wheel (R) to revolve.

The movement is very smooth, and of course free from dead centres, thanks to the fact that there are five cylinders. The exhaust gases are discharged direct into the open air from the five cylinders, and the ignition is effected by electricity by means of a Bunsen cell (A) and an induction coil (D).

The handle-bar (*f*) controls the steering-wheel (F) in the usual way, and a press-button (*a*) must be continually depressed by the rider's thumb, in order to ensure the passage of the spark which causes the ignition. This arrangement, which at first sight may appear troublesome, has this

advantage, that when by reason of a spill or other accident or cause, the action of the rider ceases, the circuit is at once broken, and as no spark can pass the machine stops.

The total weight of the Millet bicycle is 50 kilos (1 cwt.); the driving-wheel (R) measures 80 centimetres (2 ft. 7½ in.), and the normal rate of speed is 180 revolutions per minute; at this rate the engine develops a force of 50 kilogrammetres (360 foot lbs.), and the speed is 27 kilometres (16¾ miles) per hour. If the rate is forced up to 300 revolutions, which will increase the development by a little over 1 H.P., a speed of 45 kilometres (28 miles) per hour may be attained.

The Hildebrand and Wolfmüller bicycle was brought out in Paris by Messrs. Duncan and Suberbie, shortly before the Second Cycle Show in December 1894.

Like the preceding one, it resembles an ordinary safety bicycle, but it has the drawback of being without treadles; while travelling the feet are placed on two foot-rests (P). Apart from this disadvantage it seems rather superior to the Millet machine, both as regards strength and general arrangement (Fig. 20).

The front steering-wheel (F) is an ordinary bicycle wheel; the driving-wheel (R) is a disc-wheel, and measures 56 centimetres (1 ft. 10 in.) in diameter, with a 52 mm. (2 in.) pneumatic tyre.

The frame is fitted with eight weldless steel tubes, forming two quadrangular prisms joined at the base (AB and A′B′); the four tubes (AB) forming

the ascending oblique part in front, and the four other tubes constituting the horizontal portion. The eight tubes are firmly connected by tubular cross-stays, so that the whole machine, which is of great strength, may be easily ridden by cyclists of either sex.

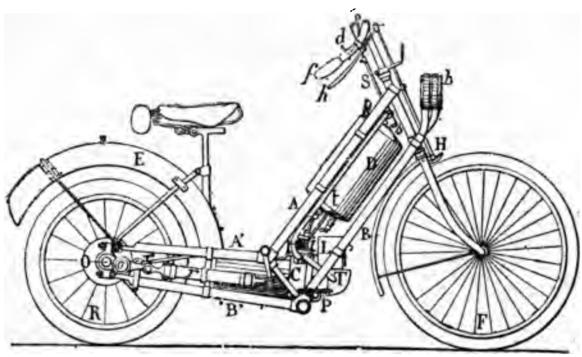


FIG. 20.—The "Hildebrand and Wolfmüller" Bicycle.

The double-cylinder motor (C), being lodged in the horizontal part, is thus fully protected from shocks and damage, even in the event of a fall.

The petroleum is stored in the reservoir (D), from whence it flows through the valve (*s*) and the pipe (*t*). This valve serves to regulate at will the supply of hydro-carburet, according to the degree of strength imparted to the explosive compound; it is worked by the rod (S), which the rider, as he holds the handle-bar (*f*), can regulate by means of the milled wheel (*d*).

Air is admitted through a "rose" fitted with a gas-fitter, and is conveyed through the tube (B)

simultaneously with the desired quantity of petroleum, to the throttle-valve (I). The burnt gases are expelled through valve (*i*), which is worked by rod (*e*); they pass off through the tube (T) which terminates in a bell-mouth which serves to deaden the noise of the exhaust.

The **Pennington Motor**, constructed by Mr. Kane of Chicago, has been highly praised in the American papers, particularly in the *American Machinist*, but

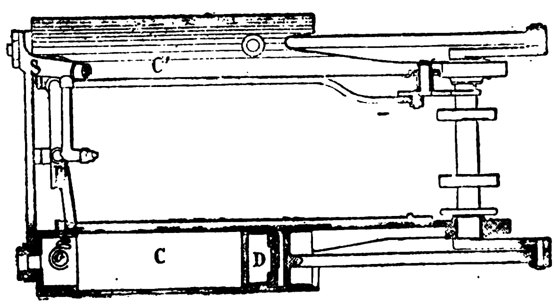


FIG. 21.—The "Kane Pennington" Motor. (L. A.

we have no means of judging the value of these eulogies until we see a bicycle in France fitted with this appliance, and so far this seems to be a pleasure in store.

The Pennington Bicycle, of which we append a sketch, Fig. 22, will give our readers an idea of this arrangement.

The motor, designed on a larger scale in Fig. 21, has two cylinders C, C′, with cranks keyed to the rear axle at an angle of 180° to each other.

The cycle is effected in four stages. The petro-

leum contained in a reservoir (D) passes to a smaller distributing reservoir (A), which feeds it direct into the cylinders through the bifurcated channel (*p*); it falls on a metallic wire which is in connection with the igniter (*o*); and a mechanism *ad hoc* causes in this wire a series of contacts and interruptions which, as the *American Machinist* describes it, "discharges into the petroleum vapour,

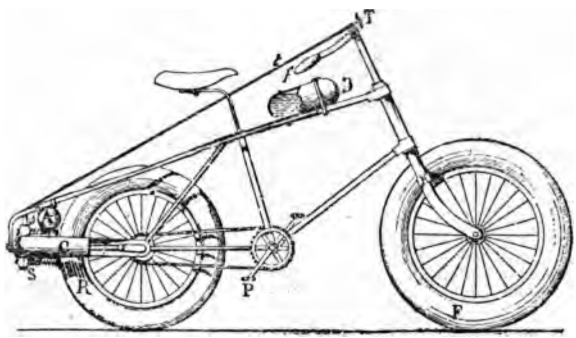


FIG. 22.—The "Kane Pennington" Bicycle.

during the period of compression, a series of electric sparks, which will assist the vaporization of the essence, without, however, raising the temperature to the point of ignition."

At the end of the return-stroke, a more powerful spark is produced at *o*, and it is this which causes the explosion.

The length of the cylinders (C C′) is equal to two and a half times their diameter, and it is to this large size that the *American Machinist* ascribes their property of cooling completely without any

circulation of water, thanks to the protracted expansion, and the conductivity of the sides of the cylinders, which are of thin steel.

The admission and exhaust valves located at S are both of them set in motion by the engine, by means of the eccentric (*e*), which is driven by a gearing keyed to the shaft ; (*s*) is the admission, and (S) the exhaust-valve (see Fig. 22).

The two cylinders are suspended on the frame, on either side of the rear driving wheel (R), which can also be worked by the pedals (P).

The front wheel (F), which is the larger one of the two, is the steering wheel as in ordinary safety bicycles; by means of a milled wheel (T), fixed to the handle-bar (G), and the rod (*t*), the admission of petroleum through the admission valve (*s*) can be regulated.

The back wheel is 55 c.m. (22 in.) in diameter, and the pneumatics are very wide.

This machine is supposed to weigh only 26 kilos (57 lbs.) and to attain a speed of from 60 to 70 kilometres (37 to 43 miles) per hour.

This remains to be seen.

The "Battey" Bicycle, shown in Fig. 23, is also made in America (not in Chicago, but in New York).

The ignition is effected by electricity, generated by a battery (H), the circuit being made automatically by contact with the rod (C) which participates in the reciprocating motion of the piston.

There seems to be no reason why it should not have been a success ; it is certainly well designed,

and it is interesting because it is of the Rotary Oil Engine type reduced, in a measure, to its simplest form, and is constructed on the principles defining our "class B *b*," and which we have described as "Detonating Expansion Motors" (see p. 17).

It is particularly original on account of its engine which is rotary, and is keyed direct to the axle (O) of the rear driving wheel (R). It consists of a bucket wheel (D) enclosed in a case (B), which is

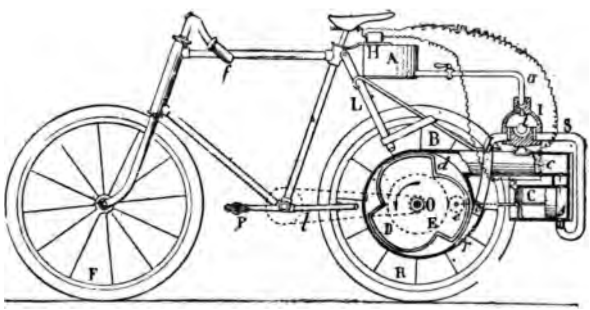


FIG. 23.—The "Battey" Bicycle.

attached to the forks (L and I) within which it freely revolves. To this same axle (O) is also keyed the pinion by means of which the treadles (P) drive the wheel (R) simultaneously with the action of the motor, or even when the latter is at rest; then there is a cogged wheel (E) gearing into a pinion (*e*), and this by means of a crank (*e o*) imparts an alternating movement to a piston in a cylinder (C).

This alternating motion draws through the valve

(*s*), into the carburator (I), some of the detonating compound which is compressed on the return of the piston and sent through other valves into the cylinder (*c*), where explosion is caused by electricity. As this cylinder discharges into the chamber (B) exactly opposite the bucket (*d*), the explosion gives to the latter an impulse, and each bucket receives its own impulse according to the ratio between the radii of the gearings (E *e*) ; hence the wheel (R) revolves and the machine advances.

The burnt gases are discharged through a tube (*b*), and becoming mixed with cold air drawn in mechanically through the apertures (*r*), they enter the carburator (I), in which the gazoline coming from the reservoir (A) falls drop by drop from the pipe (*a*) on to a ball (*i*), on the surface of which it is vaporized.

The explosive compound thus formed, and heated to a suitable temperature, is drawn into the cylinder (C), and then forced into *c*, where it is ignited.

This absolutely novel arrangement appears to us to be quite capable of practical application.

CHAPTER IX

TRICYCLES AND QUADRICYCLES

GREAT prominence has been given to the **De Dion Léon Bollée** petroleum tricycle by an amalgamation which made a great stir at the time, and which will still be fresh in the public mind.

We propose therefore to give a description of these, as well as of the "Gladiator" Quadricycle. By so doing we put before our readers the three most successful systems of light auto-motors, or small petroleum cars.

De Dion's Tricycle was designed with a view to combining a minimum of weight with a maximum of rigidity and strength (Fig. 24).

The single cylinder engine, acting in four cycles, is fitted with cooling flaps, and is fixed to the rear axle by means of three bolts ; it is mounted on a tight aluminium box, or hollow frame (visible from the back of the wheel under the axle), in which the working parts revolve in oil.

The engine is $\frac{1}{2}$ H.P. ; it weighs 18 kilos. (40 lbs.), and transmits the motion to the rear axle by means of a single gear.

The ignition is effected by electricity generated

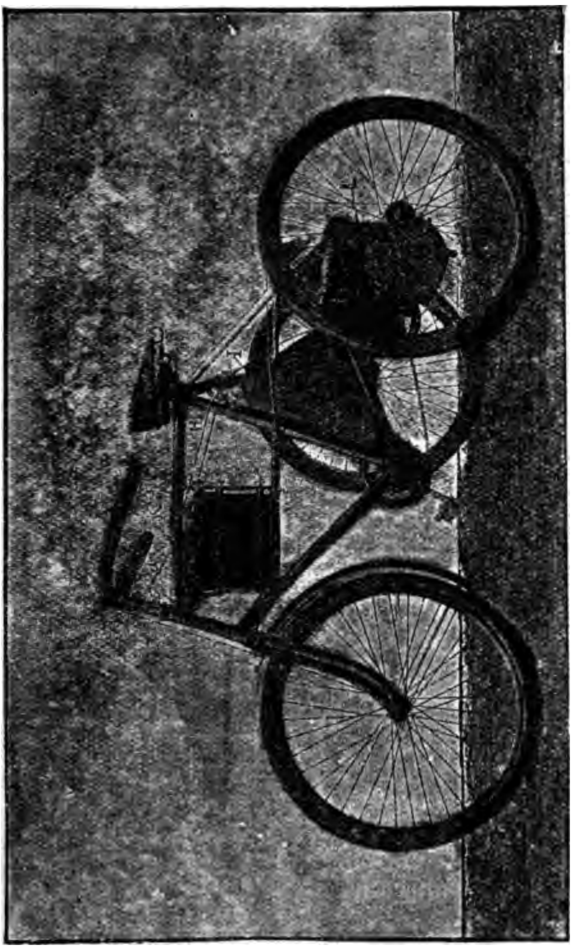


FIG. 24.—Petroleum Tricycle; De Dion and Bouton's System.

by bichromate battery cells, which are visible in the front portion of Fig. 24, behind the handle-bar. The exact moment of the contact which allows of the passage of the current in order to produce the electric spark is determined by a cam fixed on the driving-shaft; the position of this can be altered by means of a handle (H), which is within reach of the rider, and by means of this the lead required for the various speeds of the engine in order to obtain the maximum effort can be imparted to the ignition.

The carburator (I) contains about 3 litres (5¼ pints) of petroleum at 700°; it has two cocks, one (J) for introducing air and gas in given quantities calculated to secure the best detonating compound, the other (K) for regulating the passage of the compound to the motor, the speed of which is regulated by opening or closing this cock as required. The carburator is heated by a portion of the burnt gases, while the remainder escapes noiselessly through the outlet (L).

In order to start the machine the rider releases the handle (H), which controls the point of ignition; it then stands at low speed, that is to say at the highest point, and once well started the pressure cock is closed, the carburator cocks are opened; the cock (J) occupies a central position which can be regulated from the start, in order to secure proper carburation (if advanced it will only draw on the carburator, and if put back it will only draw on the atmosphere).

The cock (K) should be fully open (the handle

pushed to the front), and the handle (M) of the guide-bar should be set at start. Immediately an explosion occurs the treadles are thrown out of gear, and all that the rider has to do is to regulate the compound by adjusting the cock (J); the admission is controlled by the other cock (K) according to the speed desired, and the point of ignition must then be adjusted accordingly.

When the rider desires to stop he at once prevents ignition by turning the handle (M) of the guide-bar, and if necessary he uses the brake; if he desires to stop the motor when going down hill, or under any ordinary circumstances, without, however, arresting the motion of the tricycle, he closes the regulating cock (K), interrupting the ignition at M. To set the motor going again, complete the circuit by turning the handle and opening the cock (K); then a few turns of the treadle are required.

The three litres ($5\frac{1}{4}$ pints) of petroleum contained in the carburator will be a sufficient charge for a run of from 70 to 100 kilometres (43 to 62 miles), according to the condition of the road, the direction and the strength of the wind, and the weight to be carried; the latter should not exceed 110 kilogrammes (2 cwts. 18 lbs.). On a level road a speed of from 20 to 35 kilometres ($12\frac{1}{2}$ to $21\frac{3}{4}$ miles) may be attained, and without using the treadles gradients of 4—6 in a 100 may be climbed. If the motor is assisted by pedalling then gradients of from 10—12 per 100 can be climbed. The crank is so arranged that the treadles are thrown out of

gear as soon as the feet cease to bear on them; they serve as foot-rests, but are automatically thrown into gear again by the slightest effort in the way of forward pedalling.

A powerful progressive brake is worked by a lever placed below the handle-bar within reach of the rider, so that he has absolute control of the machine.

The Léon Bollée tricycle was patented on December 4, 1895; it is therefore one of the most modern auto-cars patronized by the public.

Monsieur Léon Bollée has not adopted any particular or special motor for his tricycle; his invention consists merely in a very simple manipulation of the gear, the brake, the manipulating levers, and the frame.

On this machine, which is as simple as it is strong, are arranged two tandem saddles, thereby offering a minimum resistance to the wind; the cushions and back-rests are fitted with springs, and the riders may without difficulty wear capes.

This machine when running weighs 160 kilogrammes (about 3 cwts. 12 lbs.), and is of 2 H.P.; it is very strong, owing to the low position of the centre of gravity, 40 centimetres ($15\frac{3}{4}$ in.) from the ground, as well as to the large triangular supporting surface, $1{\cdot}10^{m.} \times 1{\cdot}25^{m.}$ (3 ft. 7 in. × 4 ft. 1 in.).

The frame (see Figs. 25 and 26) consists of two tubular bars, 1 and 2, connected by cross-pieces 3 and 5, and by an intermediate cross-stay (4), also of tubular steel.

The cross-piece (3) has a vertical socket (D D′)

at each of its extremities, and these sockets carry the pivots of the steering wheels (F and F′), forming "the double, or pivoted fore-carriage, Bollée's American system, patented 1873."

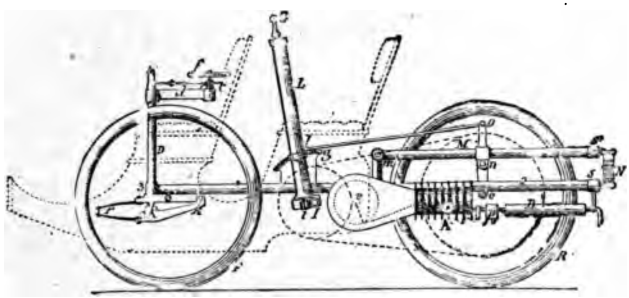


FIG. 25.—Léon Bollée's Tricycle (elevation). (Fr. A.)

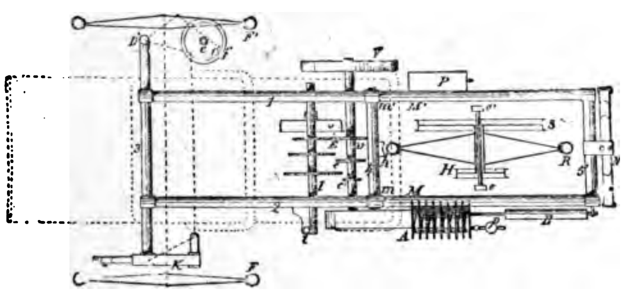


FIG. 26.—Plan. (Fr. A.)

Finally, a horizontal tube (*d*) attached to the socket (D) supports the hand-wheel (*f*), which controls the pivots by means of the pinion (*c*) and the rack (C). Both of the axles of the front steering

wheels (F and F′) are carried on links (K), jointed at *k*, and fixed on to the frame; the two branches are connected by the springs (*r*), so that the fore-carriage hangs very easily, and does away with the necessity of having an axle, which oscillates with the springs and traverses the car.

The single-driven wheel (R) at the back is supported on a U-shaped arrangement, the two branches of which (M and M′) rest on the tubular bars (1 and 2) at the ends of the stay-tube (4), and are joined at *m m′*. The cross-piece (5′) which forms the base of the U rests on the end of the frame by means of a double transverse spring (N). There is an articulated link on this U-piece at N, on which rest the extremities of the axle of the wheel (R) at the point *o*.

The three wheels run in ball-bearings, and are fitted with steel phantom wheels on tangent spokes. These are provided with pneumatic tyres 65 millimetres × 15 millimetres ($2\frac{1}{2}$ in. × $\frac{19}{32}$ in.) thick, and these may be regarded as punctureless. Any kind of motor may be used, but M. Léon Bollée fitted up his first automatic tricycles with a very simple petroleum engine, requiring neither water nor electricity. The cylinder (A) is suspended laterally outside the frame, so that all the working parts are visible and accessible; the carburator is at *p*, and the expansion chamber for the gas-exhaust is at B. On the other side and symmetrically arranged, is placed the petroleum reservoir (P). The connecting-rod and crank-shaft revolve in oil inside a gear-case (carter), from the side of

which projects the shaft (v), having a fly-wheel (V) at the other end, and fitted longitudinally with three spur-wheels (E, e, and e'), which give three different speeds when connected with the wheels and corresponding pinions keyed on to the counter-shaft (I); these speeds are respectively 8, 15, and 25 kilometres (5, 9, and 15½ miles) per hour. The average consumption of petroleum represents about two centimes per kilometre (about one-third of a penny per mile), and one charge is sufficient for a run of from 120 to 150 kilometres (74 to 93 miles).

The counter-shaft (I) is arranged so as to slide in its bearings, and displace the gear without displacing the pulley (s), which continues to revolve.

This result is obtained by means of the manipulating lever (L), which is hollow so as to enable it to carry a spindle with a pinion (i) at its lower extremity; this pinion gears into a ratchet on I. This pinion can be turned by means of the handle (G).

The motive power is transmitted by a belt running between the pulley (s) and a pulley (S) keyed on to the axle of the wheel (R). In a corresponding position on the opposite side to S is a brake-pulley (H), also keyed on to the axle.

As the extremity (O) of the link (n o) is connected with the lever (L) by means of a connecting-rod (O 1), it will be seen that if the lever is pushed forward the axle of the wheel (R) is shifted backwards, and *vice-versâ;* hence it is easy, by simply moving this lever, to increase or relax the tension of the belt, and also to heighten the tension

of the steel band which acts as a brake on the pulley (H); if the axle of the wheel (R) is still further moved forward, the tyre of the wheel is brought moreover into contact with the brake-block (*h*). The position of the lever (L) (which may be made stationary at will on the circular ratchet (*g*), in which the gearings for speed-changing can be used) is such that the belt is always released.

The Gladiator Quadricycle is particularly remarkable for its elegant and comfortable appearance, and for the ease with which it can be managed, and its simple and substantial mechanism kept in order.

The Gladiator Motor, acting in four cycles, consists of two horizontal twin cylinders (C) of 4 H.P., and these are arranged in a cylindrical box (B) which forms the frame (see Fig. 27).

The connecting-rods attached to the pinions are coupled on the same crank-pin, that is to say, they are mounted side by side. At the sides the frame is enclosed by two covers, which are hollowed out at the centres to serve as bearings for the shaft.

This shaft has two pinions of different diametres on the outside of the frame, giving two speeds, the ordinary speed for level roads or slight gradients, and reduced speed for steeper gradients.

The low-speed pinion gears into another with a number of double teeth, the spindle of which is fitted with two symmetrically-arranged cams (*c c'*), which cause the alternate raising of the exhaust-valve (*s*). For this purpose two double levers (T),

arranged in juxtaposition, are pivoted independently of each other on to a common axis, and the extremity (*t*) carries a roller, which is always kept, by means of the spring (*r*), in contact with the surface of the cams adapted for the purpose; the other extremity (*t'*), which is curved, rests when required on the end of the exhaust-valve stems (*s*).

The throttle-valves (S) are automatic, and act by suction; they admit the explosive mixture into the cylinder during the first cycle, in proportions

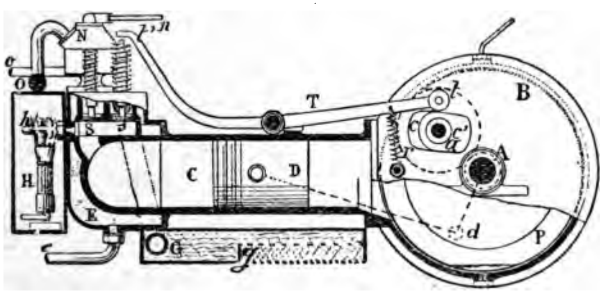


FIG. 27.—The Gladiator Motor. (L. A.)

regulated by the cock (*n*) of the carburator (N). During the second cycle, the piston (D) compresses the mixture at the bottom of the cylinder, the lower end of which is cooled by circulating water. In the third cycle, the ignition of the compound is effected by contact with the platinum tubes (*h*), which are made red-hot by burners (H) fed with petroleum; an explosion ensues, forcibly displacing the piston (D), and thus giving rise to propulsion. Finally, in the fourth cycle, the burnt

gases are passed through the channels (*s* G) into the box (*g*), which is filled with iron-scale to deaden the noise, and thence discharged into the open air.

The carburator acts automatically, and the air drawn in by suction is heated to facilitate the vaporization of the carburating liquid.

Before being introduced into the cylinder, the carburated air is mixed with a quantity of pure air, the admission of which is regulated by a cock placed within easy reach of the driver. Intermediate speeds can thus be obtained by varying the strength of the mixture.

As regards the carburated vapours, their composition in the carburator is almost uniform, as the action of the carburator is regulated automatically, a new supply of fresh liquid replacing that consumed in the process of vaporization in proportion as required. Any heavy residues formed are cleared away from time to time by means of a cock fitted to the lower part of the carburator.

The normal speed of the engine is 680 revolutions per minute, which will enable the vehicle to run at from 9 to 30 kilometres (5½ to 18½ miles) per hour. The consumption of oil varies from 1 to 1¼ litres (1¾ pints to 2¼ pints) per hour, according to the amount of work exacted from the motor.

The cost of lubrication is almost nil, about half a pint of pure mineral, poured into the closed frame, will be enough for a five hours' run; the crank discs, by their rotary motion, ensure perfect lubrication by simply projecting the oil.

A reservoir holding 30 litres (6½ gallons) of water serves to cool the explosion chambers and valve-boxes; this is placed at V in the front-part of the vehicle, so that it may be kept cool by the current of air it encounters as it runs.

Fig. 28 shows a side-view of the vehicle; it may be fitted with two or three seats as required; the

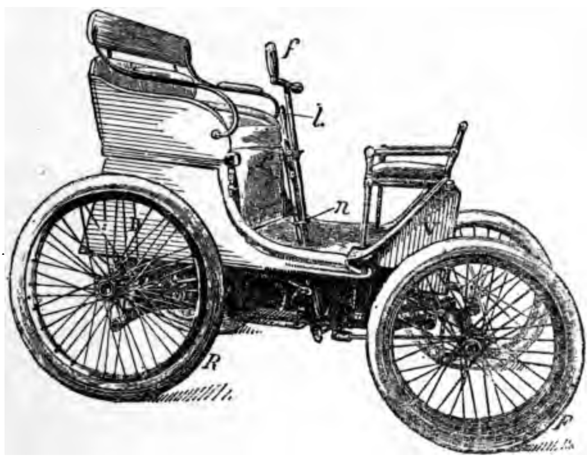


FIG. 28.—The "Gladiator" Quadricycle. (L. A.)

front seat may be used for a child, or if turned down it will afford room for two cwts. of luggage. The back driving wheels (R) are 75 centimetres (2 ft. 6 in.) in diameter, the front steering wheels (F) are 65 centimetres (2 ft. 2 in.) only; all are finished as cycle wheels, with tangent spokes and pneumatic tyres. The frame is made of cold-drawn steel tubes.

The traveller has the steering-lever (*f*) within easy reach of his hand, so that he can control the front wheels (F), the lever (*l*) for altering the speed, the carburator-cock (*p*), and close to his foot is the treadle which actuates the brake.

The oil-reservoir, to hold 20 litres (4½ gallons) of petroleum of a density from 690 to 700, is placed under the principal seat at D.

The total weight of this little car does not exceed 200 kilos. (4 cwts.); it is easily managed, and is very strong, as the centre of gravity has purposely been placed very low.

There are, of course, many other light vehicles now patented, or in course of construction, but we believe we have acquainted our readers with all those which are of special interest.

Petroleum auto-cars, which we will now proceed to describe, are likewise very numerous; new designs are introduced every day, and in the Paris to Marseilles road-race several hitherto unknown vehicles competed.

The reader will understand our difficulty, and doubtless thank us if we restrict ourselves simply to those which have been satisfactorily tested, and which have shown by actual use for a reasonable time that they are fairly deserving of recommendation.

CHAPTER X

PANHARD AND LEVASSOR'S CARS

"DAIMLER" MOTORS

THE labours of M. Gottlieb Daimler, who in 1889 became associated with Panhard and Levassor, constitute an uninterrupted series of improvements, both in regard to motors with explosive action and auto-cars, extending, as far as we are able to ascertain, over the period from January 16, 1884, to August 29, 1895.

M. Daimler had already taken out a patent in France on September 23, 1882, under No. 151,236, for an "Improvement in Friction Clutches."

Daimler's **First Patent**, referring to detonating motors, No. 159,759, dates from January 16, 1884. It is entitled, "Improvements in Gas and Oil Motors" (Fig. 29).

The cylinder (C) terminates in a compression chamber (*c*), protected against external cooling by a non-conducting jacket. The admission valve (S) admits air mixed with gas or oil-vapour, and this compound, thanks to the pressure and to the high temperature, ignites spontaneously when the piston reaches the end of the stroke, at "dead centre."

The piston is driven forward, and the next stroke expels the gases through the valve (*s*), which is moved by the rod (*t*), and so on, as in all the quadruple-acting engines.

To start the engine the ignition is effected by means of a metallic fuse (A), heated by an external flame (*a*), but soon the chamber (*c*) is sufficiently heated to dispense with the burner (A).

The piston (D) is fitted inside with a lining of non-conducting material (*d*), to protect the segments situated at the other end.

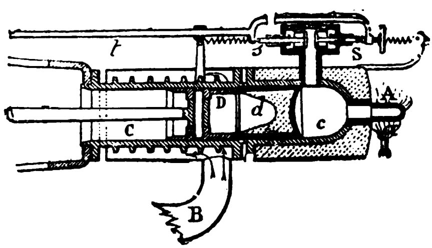


FIG. 29.—Daimler's First Patent. (Fr. A.)

The cylindrical body (C) is kept cool by ventilation; an air-current introduced through the pipe (B) circulates round the blades, and escapes at the front part of the cylinder.

There is nothing in this arrangement that could give a clue to the novel arrangements of the "Daimler" Motor, which was universally known and adopted.

This first step taken by M. Daimler in the path in which he was to make such headway later on, appears to us to be an interesting one. It was,

moreover, as far as we are aware, the first attempt at a motor working with compression and with spontaneous ignition, and it does not leave much room for inventive merit on the part of the designers of more recent machines, such as the Hornsby-Akroyd and others.

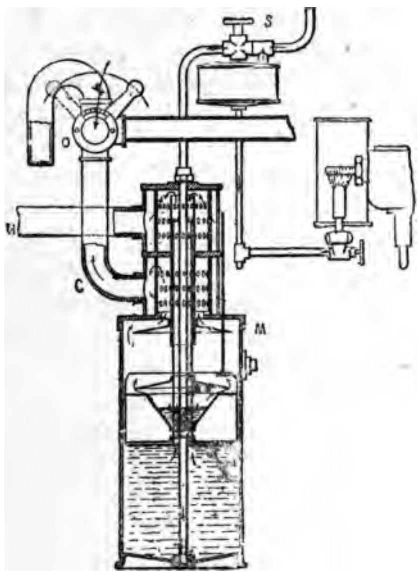


FIG. 30.—First Carburator, Daimler System. (Fr. A.)

The "Daimler" Motor (**Second Patent**) was not invented until the following year, and was patented on April 15, 1885, under No. 168,279, the patent being entitled "Gas and Petroleum Motor."

First Carburator.—The engine acts equally well

with ordinary gas and petroleum ethers, with the aid of the carburator shown in Fig. 30.

A cylindrical reservoir (M) contains gazoline, with a float at the surface. The air is introduced through H; under the influence of the suction caused by the engine during the first cycle, it descends to the bottom of the reservoir (M) through an axial tube, and after bubbling up through the liquid it will pass through C, to the explosion-chamber, which it reaches mixed with a certain quantity of pure air, regulated by the three-way cock (O).

This is a subsidiary reservoir, feeding the lateral burner (*h*), which serves to heat the incandescent igniter of the compound at the bottom of the cylinder.

The engine acts in four stages and has one cylinder; Fig. 31 shows it in cross-section and Fig. 32 in elevation, with the face (P) of the fly-wheel disc (PP').

As the reader will observe, all the driving parts, the connecting rod and fly-wheel discs, are enclosed in a box (B), constituting a hermetically closed frame, from one side of which projects the shaft (A) carrying the pulley (N).

The first cycle is the period of the charging stroke, during which the explosive compound supplied by the gas-inlet (*g*) enters the cylinder (C) through valve S, mixed with a considerable quantity of air and with a slight loss of pressure, owing to the resistance of the spring and of the bubbling action. This lack of pressure is made up towards the end

of the stroke of piston (D), when the valve (E) which it carries at its bottom is opened by impact with the fixed fork (*d*), whereupon the cavity of the hollow frame (B) is filled with compressed explosive mixture which serves to complete the charge in the cylinder (C).

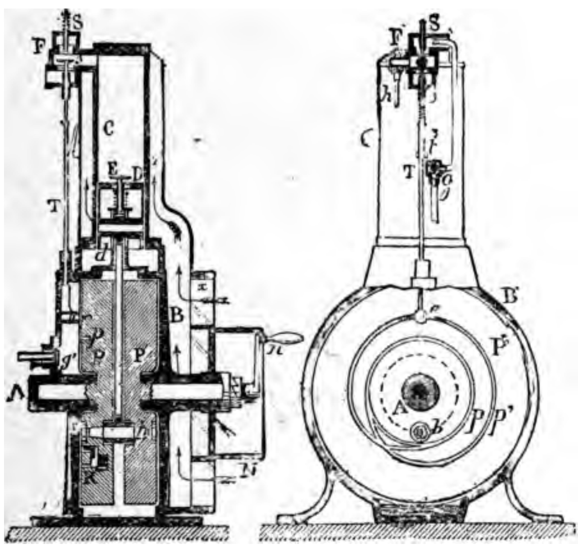


FIG. 31. FIG. 32.

One Cylinder Daimler Motor.

In the second cycle or period of compression the valve (S) closes, and while the piston (D) compresses the compound in the cylinder, it at the same time draws some of the explosive compound into the chamber (B) through valve *g*.

Ignition is effected by means of an incandescent tube heated by the fixed burner (*h*). A cam (*t*) placed on the distribution-valve rod (T) shuts off the gas-inlet (*g*) at the end of the suction stroke, thus causing the valve (S) to admit a poorer compound, which, filling up the space near the incandescent tube, will prevent premature ignition.

The third cycle, subsequent to the ignition, is the period of the useful stroke, while the fourth is the period of the return stroke of the piston, during which the burnt gases are expelled.

At the commencement of this fourth cycle the valve (E) raised by fork (*d*), admits a blast of gaseous compound in order to clear out the cylinder (C), but soon after the valve (E) closes, and the piston draws into the chamber (B), through valve *g′*, some gaseous compound, which will then be compressed by the subsequent downstroke.

The exhaust-valve (*s*) has meanwhile been opened by the rod (T), the lower end of which bears a shuttle (*o*), which travels in the double groove (*pp*) cut into the outer face of the disc (P). In the regular course of action, the shuttle will freely pass from groove (*p*) to groove (*p′*), so that in the fourth cycle the rod (T) is raised just to the point of lifting the valve (*s*). If the engine runs too quickly, the action of a special governor arranged in the disc P, at R, will prevent the shuttle (*o*) from passing into the groove (*p*), so that it is compelled to make its second round in the groove with the minimum radius (*p*), the result being that as the rod (T) does not rise it cannot

lift the valve *s*. Consequently the burnt gases will not be expelled, but will "cushion" against the piston (D), hence causing a slackening of speed until the shuttle (*o*) passes again into the groove (*p*).

We will not describe the governor (B), which has not been retained in the "Daimler" motors; its action was not absolutely reliable, and it has therefore been replaced by the system which we are about to describe, together with the second "Daimler" motor.

The engine is started by turning the crank (*n*), which is held fast on the spindle (*a*) by a pawl, so that the engine can start to work without carrying the crank with it. The cylinder (C) is cooled without water by the circulation of a current of air caused in the chamber (Z) by the movement of the ventilator (*x*).

Thanks to the introduction of new and truly original arrangements, this motor exhibited, from the first moment when it was tried, a real saving in fuel; an engine of 1 or 2 H.P. running at 700 revolutions per minute, only consumed 1000 litres (33 cubic feet) of gas per H.P. per hour; and one of 6 to 8 H.P., running at 450 revolutions, about 800 litres (28 cubic feet); its only fault was that it was a little noisy.

Daimler's **Third Patent**.—The comparative lightness, and the compact grouping of the parts of this engine, suggested to the inventor the idea of using it for working a bicycle which he constructed

in the course of the same year, 1885, and which we have described in Chapter VIII., pp. 64—66.

The subject of Daimler's **Fourth Patent**, No. 179,236, of October 26, is a "boat propelled by a gas or petroleum motor;" this boat, fitted with the single cylinder engine, was abandoned when Mr. Daimler invented his double cylinder engine.

Fifth Patent, in 1887, December 27, No. 187,828, for a "Vehicle with wheels driven by gas or petroleum motor."

This is a kind of omnibus with seats arranged lengthways, built for running on rails; the engine with one cylinder is placed at the side in the middle of the vehicle. It works a first transverse shaft by a friction-coupling, and in the second place an intermediate shaft, which, by means of gearing, transmits its movement to the front driving-axle.

The connection between the first and the second shaft is effected by three pairs of gearings, which can be thrown into gear at will so as to change the speed. This vehicle, which excited much interest at the time, was exhibited by Messrs. Panhard & Levassor at the Universal Exhibition in 1889.

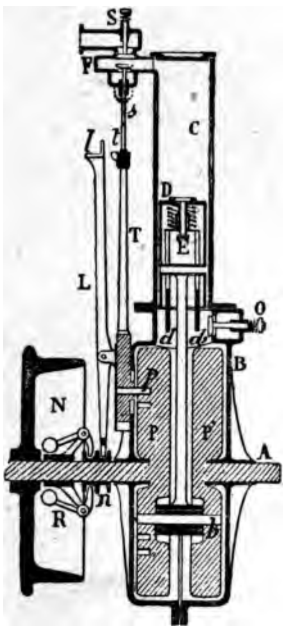
"Daimler" Double Cylinder Motor (**Sixth Patent**) (No. 199,024, June 18, 1889).

Fig. 33 shows it in cross section, and Fig. 34 in front view, with one of the cylinders in section.

This engine acts in four cycles like that with one single cylinder, and the pistons are arranged so that one is in the position corresponding to the

first or third cycle while the other is in that of the second or fourth cycle.

Under these circumstances, when the two pistons recede from the bottoms of the cylinders, one drawing in the charge while the other is driven by



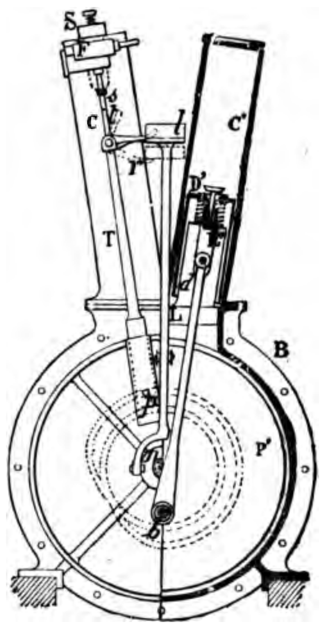


FIG. 33. FIG. 34.
Daimler Motor, with two coupled cylinders.

the explosion, both of them are at the same time forcing air into the cavity of their air-tight frame (B).

The two cylinders (C and C′), slightly in-

clined out of the perpendicular, are closed at the upper part, and attached at their lower open end to one single frame (B), which is hermetically closed, and from which the two ends of shaft A issue through two stuffing-boxes which form the bearings.

This shaft (A) is made in one piece with two discs (P and P′) connected by a single pin (*b*), to which the two heads of the piston-rods (D and D′) are joined. These attain the bottom of their stroke together when the pin (*b*) is on the line bisecting the angle formed by the axes of the two cylinders (C and C′); the outer end of this shaft carries the driving-pulley (N) as well as the governor (R).

When the end of the stroke is reached the forks (*d d′*) raise the valves (E E′). Thereupon the compressed air contained in the chamber (B) passes to the back of the pistons; in the suction cylinder, this air mixes with the carburetted charge so as to supply the quantity of oxygen required for the explosion; in the cylinder which has just finished its active course this air drives before it the residual combustion gases, thereby completely expelling them. Consequently the cylinder is thoroughly cleansed from the products of the explosion, contrary to what generally happens in engines acting in four cycles, but the pistons (D and D′) in returning towards the bottom of the cylinders have meanwhile produced in the chamber (B) a partial vacuum, causing the valve (O) to open, through which air enters.

A box (F), fitted at the top of each cylinder, serves to effect the admission and expulsion by the combined action of the two valves (S and *s*).

The valve S, which communicates with a carburator, opens automatically during the period of suction in order to admit the carburetted vapour,

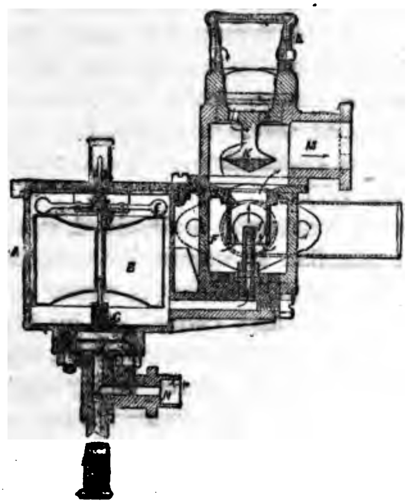


FIG. 35.—Daimler's Second Carburator. (Fr. A.

while the exhaust-valve (*s*) is pushed open at the proper moment by the tappet (*t*), supported by the extension of rod T, which is itself worked by the driver (*p*), travelling in a groove cut in the face of disc P, and in this it takes two rounds before getting into position for opening the valve.

Ignition is obtained by means of an igniting

apparatus fixed at the side of box F, and heated from outside. The whole is protected from dust and all external disturbances by a metal casing.

The Second Carburator, applied by M. Daimler to this new motor (Fig. 35), differs a little from that which we have previously described. The admission of gazoline takes place at the lower part of reservoir A, at N, through the axial channel (O); a valve (C) suspended on the rod D is arranged so as to close automatically, thanks to the action of the levers (E), which are pushed up by the float (B) as soon as a suitable level has been attained in the reservoir (A).

This level, constantly maintained, is such as to cause the gazoline to constantly ooze out at the orifice of the lateral nozzle (I), where it is immediately vaporized and carried off by the current of air coming from the chamber (F), which plays round the orifice, its power being regulated by valve K, which can be adjusted from outside by means of the key (L). The carburetted air passes thereupon to the cylinders by the large conduit (M).

The action of the motor is controlled direct by the governor (R), acting on the collar (*n*), which displaces the lower end of the lever L (Fig. 34); the other extremity is fitted with a bracket (*l*), and when the speed is excessive this bracket acts on the lateral lever-arm (*r*) and displaces the tappet (*t*), with the result that the valve (*s*) is no longer pushed open and the residual gases cannot be expelled.

The motor is started by turning a crank fitted

to the end of shaft A, on the opposite side to pulley N. The sides of the cylinder are not cooled by any special process; the bottoms alone are cooled by a current of water.

Daimler's Seventh and Eighth Patents were taken out on the same day, viz. August 20, 1890.

No. 207,737, "Cooling of Gas or Petroleum Motors by Water and Air in combination."

No. 207,738, "Improvements in Cars and Vehicles driven by a Gas or Petroleum Engine." This is a kind of auto-motor omnibus with rear driving axle, the governing parts for its control being placed within easy reach of the driver, and the mechanism being arranged in a manner analogous to that indicated in the Fifth Patent (No. 187,828), which was subsequently adopted, with some slight modifications, by Messrs. Panhard and Levassor for their motor-cars.

Panhard and Levassor's First Patent dates from August 24, 1891, and is entitled "Improvements in Gas-Engines." The subject of the patent is a new system of ignition by an incandescent tube, applied to "Daimler" motors.

Daimler's Ninth Patent, No. 232,538, August 30, 1893, is entitled "Improvements in Gas and Petroleum Motors." This goes back to the inventor's first idea, as to spontaneous ignition, but this second attempt, owing to its later date, is far less interesting than the first.

Daimler's Patent, No. 205,518, January 15, 1894, was taken out for a clutch mechanism; it is not of any interest except in matters of detail, any more

than that taken out January 25, 1894, by Messrs. Panhard and Levassor for a compound friction clutch.

"PANHARD AND LEVASSOR" CARS.

The cars built by Messrs. Panhard and Levassor are among the number of those which appear to have reached the highest degree of comparative perfection; they rank among the most highly

FIG. 36.—Bordeaux-Paris Winner. (L. A.)

reputed systems, and attained the best results in the great trial races from Paris to Rouen and from Paris to Bordeaux and back.

The comparative lightness of the Daimler Motor, thanks to its very rapid rate of rotation (700 revolutions per minute), which takes place in oil under the most favourable conditions in the interior of a closed drum, naturally attracted the

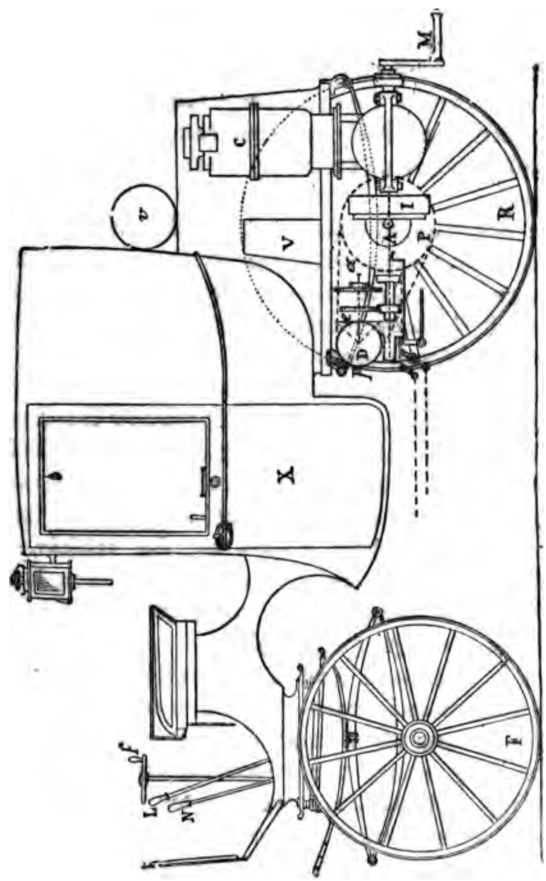


FIG. 37.—Panhard and Levassor's Patent, No. 245,276. Adjustable Motor. (Fr. A.

attention of Messrs. Panhard and Levassor, and induced them to choose it for propelling their cars. At present a 4 H.P. double cylinder engine does not weigh more than 150 kilos. (3 cwts.). Thus the petroleum car for two persons which came in first in the race from Paris to Bordeaux and back only weighed 600 kilos. (12 cwts.) when fully equipped (Fig. 36).

The only patent taken out by Messrs. Panhard and Levassor with reference to their cars bears No. 245,276; it dates from February 21, 1895, and is entitled "Improvements in Vehicles propelled by Gas or Petroleum Motors."

It is intended to meet the requirements frequently expressed by owners of ordinary carriages, who inquire whether it would not be possible, without much difficulty, to fit their vehicles with a motor system, so that they could easily and rapidly harness their horses to the vehicle, or attach the auto-motor apparatus, and thus have the option of using either mode of travelling in their own carriages (Fig. 37).

Messrs. Panhard and Levassor describe their arrangements as follows—"Wooden or metal frame fitted with two wheels and bearing the oil engine, the driving gear, the disconnecting gear, the reversing and variable speed gear, the steering apparatus, the water and oil reservoirs, etc., the whole arrangement, if it can be kept in equilibrium, to run automatically, and arranged so that it can be fixed by a few bolts either to the front, or better still to the back, of an ordinary carriage."

The motor (C) is directly connected with a disengaging friction gear (I), which can be made at

FIG. 38.—Phaeton. (L. A.)

FIG. 39.—Covered Dog-cart. (L. A.)

will to drive the horizontal shaft or axle (A) situated in the diametrical plane of the car (in the

particular case illustrated, a *coupé*, X). It communicates with an upper shaft (*a*), situated in the same plane by means of three sets of spur-wheel gearings, so as to obtain various speeds by means of the action of these gears.

The shaft (*a*) terminates in a bevel wheel (*e*), which can be made to act at will either to the right or to the left, on the box (D) of the differential gear, so as to run either backward or forward. A wheel (*p*), fitted to the outside of the differential gear-box, communicates the rotary movement by means of a chain to the gear (P), keyed on to the nave of the driving-wheel (R).

Levers L and N, fitted to the seat, act on horizontal rods, traced in dotted lines, so as to effect the throwing into and out of gear, reversing, etc.

The steering is done by means of a hand-wheel (*f*), acting direct on the bolster-pin or pivot of the front wheels (F), which run loose and serve to steer the carriage.

The water-reservoir is at V and the oil-reservoir at *r*, and at M there is a crank for starting the engine to work.

This arrangement, being directly suggested by those adopted by M. Daimler in his motor cars (Fifth and Eighth Patents), is very similar to the one eventually adopted by Messrs. Panhard and Levassor in their 1895 pattern, shown in Figs. 38, 40, 41, and 42. This is a carriage arranged to seat four persons, weighing 700 kilos. (14 cwts.) in running order.

This arrangement can also be fitted to the hooded dog-cart (Fig. 39).

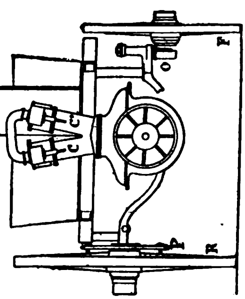
The Daimler Motor with its two cylinders (C and C′) is placed in front in a closed case (B); it is worked by means of a friction gear (I), a shaft (A), seen in the vertical plan showing the diameter of the vehicle, and this shaft is connected with a shaft (*a*), seen below in the same plan, by means of three pairs of spur-wheels. These gears may be disengaged by means of the lever L; four different speeds may be obtained, viz. 6, 13, 20, and 27 kilometres (4, 8, 12½, and 17 miles) per hour.

The back end of the shaft (*a*) is fitted with a bevel wheel (*e*); this may be made to gear into the bevel wheel (E or E′) for backward and forward motion respectively; the wheel E or the wheel E′ is thrown into gear by means of the lever N, which acts on the coupling (*n*); a differential gear contained in the case D distributes the motive-power required for each of the back driving wheels (see R), by means of the chains connecting the spur-wheel (*p*) with the crown (*P*) bolted on to the spokes of the wooden wheels.

The steering is on the same principle as Bollée's system of coupled gears driven by the lever *f*, acting on a square (*f c c′*), the ends of which actuate the connecting rods (*c o*), thus causing the axle (*O*) of each of the driving-wheels (F) to revolve.

The driver has also within easy reach the lever (*h*) of the brake (H); a second brake is worked by means of a treadle, and a support (G) may be

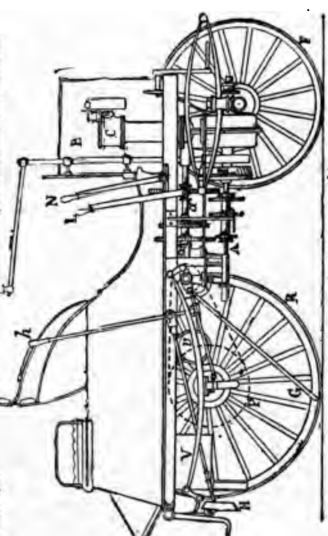
FIG. 42.



Front View, Half Front and Half Back.

Panhard and Levassor's Petroleum Cars, 1895. (Fr. A.)

FIG. 40. Sectional Elevation.



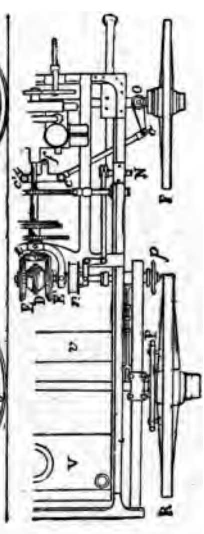


FIG. 41.—Horizontal Sectional Plan.

lowered so as to support the vehicle when climbing gradients. The actiòn of the brakes is so arranged that the gears are always disengaged to start with; by this means the motive power on the back wheels is done away with, and the driver need hàve no fear of breakage or other accident on this score.

The water-reservoir is placed at V, and the petroleum tank at *v* behind the vehicle, and they are connected with the motor by suitable conduits.

Such is the working of the mechanism which Messrs. Panhard and Levassor now employ for their vehicles, 1895 pattern, several specimens of which were exhibited in London at the Crystal Palace Show.

Vehicles of Various Patterns—The Phœnix Motor. To this pattern they also build vehicles of many other designs, such as the hooded dog-cart (Fig. 39), delivery vans with quadruple cylinder motors capable of developing from 10 to 12 H.P. by means of their new Phœnix Motor with parallel cylinders, which is simpler, stronger, and less weighty than the Daimler.

The 4 H.P. Phœnix Motor weighs 83 kilos. (182 lbs.).

The 6 H.P. Phœnix Motor weighs 135 kilos. (300 lbs.).

The 8 H.P. 4-cylinder Phœnix Motor weighs 155 kilos. (340 lbs.).

In the quadruple-cylinder motor the cylinders are grouped in pairs, and are fitted with an arrangement whereby the governors may bring the second

pair of cylinders into action according to the requirements of the road, so that the second double cylinder motor can either take part in the motion or not, according tó whether the progress of the vehicle requires greater or less power.

In conclusion Panhard and Levassor's petroleum vehicles are well built, strong, light, and quite up to the standard of recent patterns in regard to the elegance of their appearance.

The wheels are made of wood, like those of ordinary carriages; these makers regard this as a sort of *sine quâ non* which imparts a general solidity, and completely distinguishes them from other kinds of carriages.

Finally, we may add that Panhard and Levassor, like most other makers of auto-cars of the present day, are feeling their way; they recognize that they must improve on what they are doing, and without being blinded by past successes they are alive to the fact that they are far from having attained perfection.

They are approaching it by careful experiments and by unceasing toil, but unfortunately we are obliged to proceed with the issue of the present volume without waiting for their further improvements.

We have, in fact, far exceeded the period at which we had promised our volume, and we feel sure that our next edition will contain descriptions of very much improved vehicles both by Panhard and Levassor and many of their colleagues.

CHAPTER XI

THE PEUGEOT VEHICLES—ROSSEL'S CAR

DAIMLER MOTORS

EVER since the Fils de Peugeot Frères started the manufacture of cycles, M. Armand Peugeot has been determined to produce auto-cars. His first idea was to make a light tricycle, but he soon abandoned this class of vehicle, which, to his mind, had no great future before it, and devoted his energies exclusively to auto-cars.

Amongst the various arrangements which M. Armand Peugeot had occasion to examine, he was particularly struck by Serpollet's system, on account of the ingenious combinations in its boiler, and on account of its marvellous elasticity it seemed to him the complete realization of all the conditions required to drive a car.

The first adaptation of the Serpollet boiler to an auto-car was attempted in the Peugeot works, and the auto-car exhibited at Serpollet's stand in the Paris Exhibition of 1889 was built at Mandeure.

But the coiled tube with its minute interstice,

used at that time by Serpollet, was fraught with serious drawbacks.

M. Armand Peugeot, still on the look-out for a motor system which would achieve his aspirations, was fortunate at that time in coming into contact with M. Levassor and M. Daimler, who showed him a small car to carry two persons, driven by a Daimler motor which acted very well.

FIG. 43.—First Prize Bordeaux-Paris. (L. A.)

Messrs. Peugeot at once saw the advantage to be derived by the adoption of this excellent motor, and very soon afterwards, thanks to the skilled assistance of M. L. Rigoulot, the engineer to the firm, we were introduced to the auto-cars with which every one is now acquainted, and of which the practical results have proved so satisfactory, as these vehicles carried off the first prize in the two races from Paris to Rouen and Paris to Bordeaux

and back (see Fig. 43, Phaeton to carry four persons).

The first petroleum car to make a long run was Peugeot's car which, in 1891, at the time of the first great cycling race from Paris to Brest, ran from Valentigney to Paris, and then did the whole distance covered by the cyclists out and home, returning to Valentigney in excellent condition.

Fig. 46 shows a light car to seat two persons,

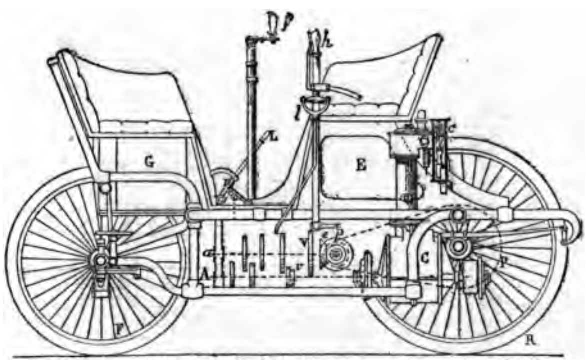


FIG 44.—Side View.

and Fig. 47 a sociable to seat four persons, the mechanism of which is shown in Fig. 44 in elevation, and in Fig. 45 in plan.

The Peugeot Cars differ essentially from those of Panhard and Levassor on account of the absence of the carriage-body. The construction is much more complicated, the frame being made of steel tubes firmly connected, and the wheels being entirely of metal, fitted with phantom spokes and pneumatic tyres.

The Daimler Motor (C), with two cylinders, together with the carburator (*c*), and the igniters, are placed at the rear; the axle acts direct on the friction gear (I), which is driven by the pedal (*n*), and may be made to drive the horizontal shaft (A) shown in the longitudinal plan of the vehicle. By means of four sets of gear wheels it is connected with a parallel shaft (*a*), situated above and at the side; these are easily thrown out of gear by means of

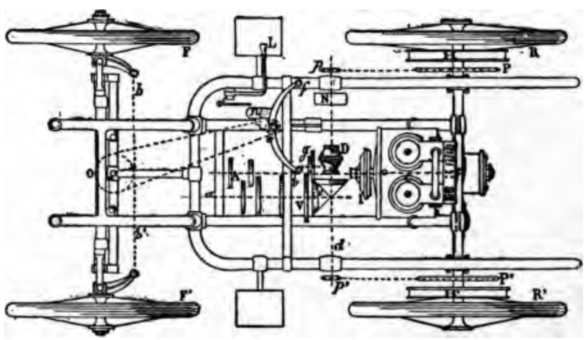


FIG. 45.—Plan.

the lever (L), and they are capable of giving four different speeds.

This shaft (*a*) has a bevel-wheel (*e*) at the back end, and this drives the counter-shaft, to which is fitted a differential gear (D), at the ends of which are the chains (*p* and *p'*); these pinions move the back wheels (R and R') by means of the chain wheels (P and P') fixed to the hubs.

The steering, which is on the Bollée system, is manipulated by the handle (*f*), which acts on the

pivots of the steering-wheels (F F′), through the medium of the pinion (*o*), the wheel (O), and the connecting rods (*b b′*).

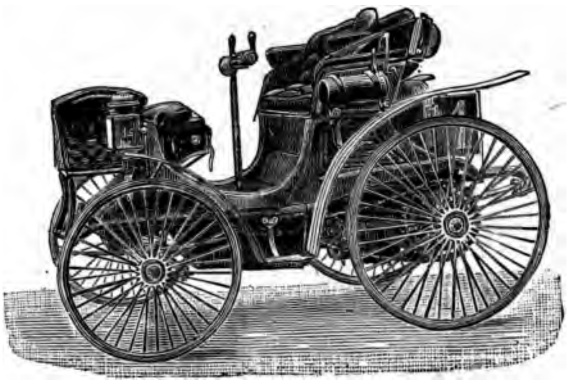


FIG. 46.—Victoria, to seat two persons). L. A.)

FIG. 47.—Sociable, to seat four persons. (L. A.)

For a temporary stoppage the lever (L) is placed at the dead centre, that is to say, in such a position that all the gear wheels between the axles A and

a are disconnected; when the stoppage is to be for any considerable length of time, the communicating cock between the carburator and the

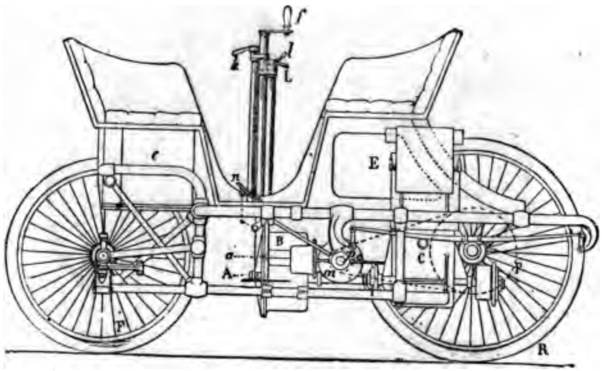


FIG. 48.—The "Rossel Car," side view. (Fr. A.)

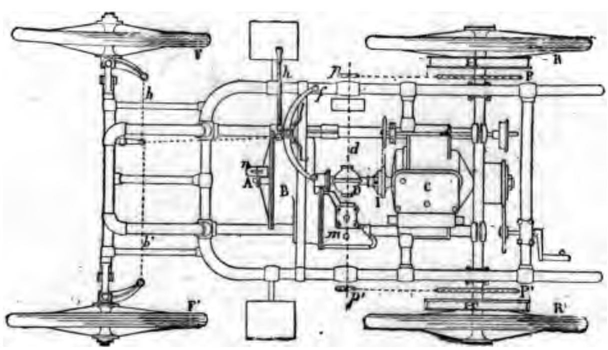


FIG. 49.—Plan. (Fr. A.)

motor is shut off, the burners are extinguished, and the brakes are shut down on to the drums (H H′) by means of the lever (*h*).

The vehicle can be backed by means of an auxiliary gear (*d*), worked by the lever (*l*), which alters the direction of the movement of the shaft (*a*) by forming a connection between the lowest speed-wheels *v* and V (8 kilometres = 5 miles).

The water-tank for cooling the cylinders is placed at E under the back seat, and the gazoline-tank at G under the front seat, that is to say, as far as possible from the burners.

This arrangement, which is both simple and strong, has been tested; it is an exceedingly good combination, and Messrs. Peugeot Frères have fitted it to many different kinds of cars (see figures 43, 46, and 47), and particularly to heavy cars constructed for the Magasins du Louvre as delivery vans.

The Rossel (De Lille) Car is also worked by the Daimler Motor.

Fig. 48 gives a sectional view of a sociable to seat four persons, of which Fig. 49 is the plan.

The Daimler Motors placed at C, by means of the friction gear (I), impart movement to the longitudinal shaft (A), to the end of which is keyed the central wheel (V) of a group of gears contained in chamber B in the front part of the car.

This wheel (V) gears continually into four wheels of gradually decreasing diameter (G, J, Q, K), each of which is cast in one piece, with four pinions (*g*, *j*, *q*, *k*); each of these pairs running loose on an axle parallel to that of the wheel (V), and these four axles are fixed to two parallel discs in the

plane of the wheel (V). These discs revolve round the wheel (V), so as to gear one or other of the four pinions (*g*, *j*, *q*, *k*) when required into the spur-wheel (*o*) keyed on to the side axle (*a*); this can be worked by means of the lever (L).

To the shaft (*a*) is fixed a bevel-wheel (*m*), which gears into the wheel (M) keyed on to the counter-shaft on which the differential (D) is placed, and this carries at its two extremities the two chain pinions (*p* and *p′*), connected with the rims (P and

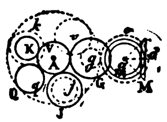


FIG. 50.—Front View of Chamber (B).

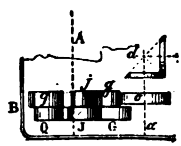


FIG. 51.—Side View of Chamber (B).

P′), fixed on to the hubs of the back driving-wheels (R R′).

It will be understood that as the lever (L) is worked by the driver, the movement thus imparted throws one or other of the pinions (*g*, *j*, *q*, *k*) into gear with wheel *o* (being held in position by a catch), the axle *a* takes an increasing velocity representing respectively 20, 15, 10, and 5 kilometres (12½, 9, 6, and 3 miles) per hour; when running at this last speed gradients of 10 in 100 may be ascended.

This handle (L) enables the driver to gear a fifth pinion (*v*) into the wheel (*o*), and this latter pinion as it is driven from *g* alters the rotary

direction of *m*, and consequently alters the direction of the vehicle.

The guide-bar (*f*) controls the Bollée steering arrangement, and acts on the front wheels (F F′) by means of the connecting rods (*b b′*); then the handle (*h*) controls the brakes, which act by means of the pulleys (H H′) on each of the driving-wheels, and by means of the handle (*l*), which acts on the governor, the speed of the motor can be slackened.

The clever combination of these three handles (L, *h*, and *l*), round the guiding apparatus (*f*), imparts to the manipulation that spontaneity and certitude which are indispensable for driving an auto-car with accuracy.

By a treadle (*n*) an auxiliary brake, acting on the counter-shaft, can be set in motion through a pulley keyed on that shaft.

The petroleum-tank is placed at *e*, under the front seat, while under the back seat at E we have the tank of water which is sent round the cylinders and thence into the hollow frame by means of a centrifugal pump.

The motor is started with the handle (*c*) connected with the axle (A) by means of a chain and two pinions.

The wheels are made of metal with rubber tyres, the driving-wheels (R R′) having tangent spokes, and the steerers (F F′) having direct spokes; the movement is thus very easy.

The carriage-work is handsome and well finished, and is balanced on a double frame made of steel tubes connected with welded couplings of the

same metal, and all communicating with one another.

This car, which was exhibited at the Third Cycle Salon, was well spoken of by connoisseurs, and particularly by persons who had had practical experience in driving auto-cars, on account of the compact arrangement of the levers, which, in other systems, are very often too far removed from one another.

End of the Daimler Motor. — After having described the equally interesting arrangements, thought out by makers who have adopted the Daimler Motor, we should observe that this motor would appear to be going out of fashion.

In fact, it has gone out, because the engines, driven by a succession of explosions, and which are now built under this name, are not Daimler Motors, strictly speaking, since they no longer possess their characteristic and original arrangement, viz., the compression of air in the hermetically-closed chamber of the frame, the object of which is to force pure air into the cylinder, and so to cleanse out completely the burnt gases.

Panhard and Levassor took the lead in this transformation when they built the Phœnix Motor, a light, strong, durable motor, possessing all the good qualities save that of being a Daimler Motor.

Armand Peugeot, when he founded the Société Anonyme des Automobiles Peugeot, the head offices of which are at Mandeure, absolutely gave up Daimler Motors; he has introduced a new motor in which he endeavours to overcome the

disadvantages inherent not only to the Daimler Motor, but to all known motors detonating by direct action.

The Daimler Motor has had its day, but it has certainly played a leading part in auto-locomotion, owing to its sterling qualities, and to the influence of its foster-parent, M. Levassor; it often happens that a child owes more to its foster-parent than to his own father.

CHAPTER XII

THE BENZ MOTORS: BENZ AND CO.'S AUTO-CARS

BENZ AND CO.'S first patent for a gas-engine dates back to March 26, 1884, and was numbered 161,209; it was taken out under the unassuming title of "Gas-Engine" (*Moteur à gaz*).

It is an engine in which the action takes place in two cycles, with compression, and is an interesting apparatus combining all the qualities of the four cycle engines, with the additional advantage that there is one explosion at each revolution. The distinguishing feature in this apparatus, shown in section in Fig. 52, and in plan in Fig. 53, is that the cylinder (A) is provided with a cover which allows the piston-rod (P) to pass through a stuffing-box, so that the piston fulfils two distinct functions: the back end compresses the compounds and receives the impulsion after the explosion, and the front end draws in the air, then compresses it in a reservoir communicating with the space behind by means of the tube E.

This portion of the cylinder is provided with two valves: *a* to let in the compressed air through the tube E, and *b* to expel the burnt gases.

When the piston commences its backward stroke, the valve *b*, forced on to its seat by a spring, is opened by the catch D, and the residues of the

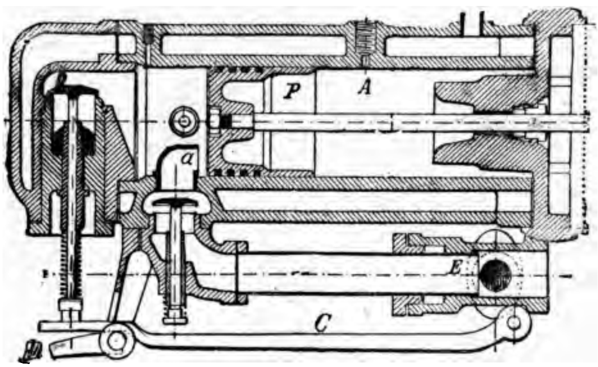


FIG. 52.—The "Benz" Motor, elevation. (L. A.)

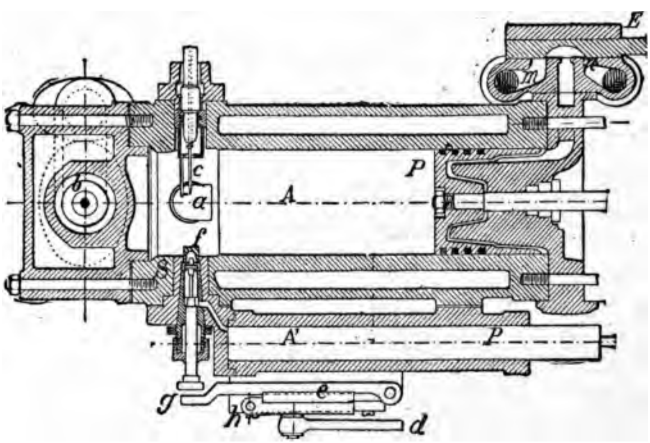


FIG. 53.—Plan. (L. A.)

combustion begin to escape; when the piston (P) has run half its stroke, the valve (*a*) is opened by the lever (C), and allows a current of pure air to rush through the tube (E) direct on to the piston; this clears out the bottom of the cylinder, and drives out the last traces of the burnt gases through the outlet *b*.

The two valves *a* and *b* close at once, and the valve S opens at the movement of the end (*g*) of the wedge-lever (*e*), the latter being acted on by the slide (*h*) driven by the eccentric rod (*d*). Piston *p* of the donkey-pump A′ then discharges into the cylinder (A) through the orifice (*f*) the necessary quantity of gas to make up the detonating compound; this is compressed by the piston (P) up to the very end of its stroke, and at that moment the electric ignition takes place at *c*.

The circulating water, coming in through the nozzle seen at the upper part of Fig. 52, cools the cylinder. At the top right-hand of Fig. 53 may also be seen the arrangement of the slide-valve (E), which regulates the suction and delivery effected by the piston (P) as the passages *m* and *n* are opened and closed for the suction and delivery respectively.

This apparatus works much more simply than one would imagine from its complicated construction. Care must, however, be taken to see that the three valves, *a*, *b*, and S, rise to exactly the height required: *b*, 9 millimetres (0·35 of an inch); *a*, 7 (0·27); and S, 2 (0·07); but all of them are of easy access. This motor, the speed of which

may vary from 150 to 250 revolutions, consumes 800 to 900 litres (28 to 32 cubic feet) of lighting-gas per H.P. and per hour.

The first auto-car patented by the Société Benz et Cie. only dates back to March 25, 1886; it was numbered 175,027, and was described as a "Gas-Engine Car" (*Véhicule à moteur à gaz*).

It was a tricycle to seat two persons, with iron wheels, fitted with metal tension spokes; one steering-wheel in front, and two back driving-wheels, connected by a differential gear.

An improvement on this patent, taken out in 1887, increases the number of seats to three or four, and substitutes for the iron carriage-work ordinary wooden wheels; the rear driving-wheels are very large, giving the whole machine somewhat the appearance of a sulky.

The main feature of these two vehicles was that they were belt-driven; they were handsomely designed and beautifully finished, and had variable speeds, in and out gear appliances, numerous spur-wheels, etc. The results, however, must have been satisfactory, if we are to credit a notice published in the American papers, in which it was stated—"On January 5, 1889, a Benz vehicle was exhibited in action at Mulheim. It was built to carry three persons, and it ran at a speed of 15 kilometres ($9\frac{1}{4}$ miles) per hour, the consumption being one litre (61 cubic inches) of benzine per hour."

The third and last patent taken out by the Société Benz et Cie., No. 230,065, is dated May 13, 1893, and is entitled—"An arrangement for driving auto-

cars, such as four-wheeled vehicles, driven mainly by a gas-engine."

In this, Benz combined his motor, acting in two stages with his mechanism on a simpler and more commodious system. This is the car first adopted and worked in Paris by M. Roger, and by the Sociétié Benz et Cie., at Mulheim-on-the-Rhine.

Nevertheless, the very ingenious though too complicated arrangements devised by Benz are now abandoned, as is also his horizontal fly-wheel, which, albeit inspired by plausible arguments, was certainly one of the most novel pieces of mechanism ever seen.[1]

The two-cycle Benz motor has also given place to a four-cycle motor, in which very little remains of the first and crude state of the ingenious arrangements introduced by Benz. It is this last arrangement which is now the standard adopted by Delmer of Belgium, Roger of France, Benz et Cie. of Germany, and Mueller of the United States.

Two models of these makers (the French and American) were seen in 1885 at the Chicago-Waukegan races, and they acquitted themselves well.

The Benz-Roger cars also competed in the two races from Paris to Rouen, and Paris to Bordeaux and back, and were classed fifth in both tests;

[1] Those of our readers who are interested in these early specimens of auto-locomotion will find a very complete description in the work by M. Gustave Richard, entitled *Les nouveaux Moteurs à gaz et à pétrole*, published by Vve. Dunod et Vicq, 49 Quai des Augustins, Paris.

they are not speedy cars, but they seem strong, comfortable, and practical machines.

FIG. 54.—The "Benz-Roger" Car, elevation. (L. A.)

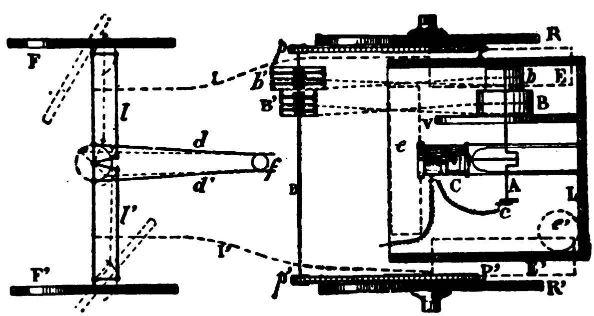


FIG. 55.—Plan. (L. A.)

Two of Benz et Cie.'s cars entered for the race from Paris to Marseilles and back.

The Benz-Roger Car, 1895 pattern, shown in Figs.

54 and 55, has been the standard design since the beginning of 1894; it was this car which arrived fifth in the two great trials in 1894 and 1895.

The single cylinder motor is placed at C; it communicates the motion direct to the transverse shaft (A), on which there is a vertical fly-wheel (V), and two pulleys (B *b*).

By means of two belts these pulleys transmit the motion to the two corresponding pulleys (B′ *b′*) keyed to the shaft (D) of the differential gear placed in front, at either end of which are the two bevel-wheels (*p p′*), and these by means of two chains transmit the motion to the two spur-wheels (P P′), thereby controlling the rear driving-wheels (R R′).

The cylinder (C) and the shaft (A), the accumulators, the water-tanks (E), the petroleum-tank (*e*), and the carburator (*e′*), are all fitted into a frame (L) hung on springs over the rear axle. This axle is connected with the front one by a light tubular frame (I I′), which carries the countershaft (D); in this way the strain from the oscillation of the suspension-springs is taken up by the belting instead of the chains; this oscillation is, however, very little felt owing to the skilful arrangement of the shafts (A D), and also to the length of the belts.

The steering is worked from the vertical shaft (*f*) by means of a hand-wheel within easy reach of the driver; this hand-wheel acts on two connecting rods (*d d′*), connected with two other rods (*l l′*) of a Bollée's steering arrangement fitted with

independent axles, on to which are pivoted the front steering wheels (F F′).

At the end of shaft A are the points of contact for the electric ignition, which is effected by means of a Ruhmkorff coil worked by an accumulator (and a spare one); in the primary circuit of this coil the wires are connected with a contact-breaker; one of the terminals of the secondary circuit is connected with the body of the machine, and the other with an insulated spring pressing against a make-and-break cam. When the spring presses against the projecting part of the cam, the current is sent through the body of the machine, but when the hollowed part of the cam is brought up to the spring the circuit is broken and a spark is made inside the cylinder between the cover and the ignition point.

These improved accumulators have sufficient spare energy for about 100 hours; they are charged by means of two Delaurier elements. The motor revolves at the comparatively low speed of 300 revolutions per minute, and its horizontal position considerably modifies the vibrations, which are very strong in all vertical motors. It is placed at the back of the car, at the average height of a man, and is accessible all over.

The general appearance of the car is very nice; it is simple and substantial, and consequently easy to handle. The changes in speed are easily effected by altering the loose pulley belts of the pairs B′ and *b*′ to the fast pulleys.

There is a strong brake, by means of which the

car can be stopped quickly, and the lever on the left of the driver is so arranged as to throw the belt out of gear at the same time as it acts on the brake.

No more Benz Engines.—Like the Daimler Motor, with which it possessed something in common, the Benz Motor has had its day. Both have failed to meet the requirement of simplicity which makers of auto-cars now insist on, a requirement which, by the way, is far from complied with by the motors acting in four cycles.

Which of these defunct motors was the better? This is purely a question of principle, and is very difficult to answer.

The Daimler evidently had a great reputation; but that, which does not demonstrate the inferiority of the Benz Motor, might simply be due to the fact that M. Levassor, who backed it up, had a longer purse than M. Roger, who was the foster-father of the Benz Motor, and, as we have said before, the foster-parent often turns out to be better than the actual father.

CHAPTER XIII

THE TENTING MOTOR: TENTING'S AUTO-CARS

French Petroleum Cars.—In the next four chapters we shall deal with motor-cars of purely French origin; the vehicles therein described have been throughout invented, designed, and made by French engineers; whereas, on the contrary, the construction of those that formed the subject of the three preceding chapters, was based on the use of the motors invented by Messrs. Daimler and Benz, both Germans.

M. Tenting, though the name savours of German or English origin, belongs to a family that has been French for generations past, and he is a mechanician by virtue of heredity.

His great-great-grandfather was the original Tenting who came to France from the Grand Duchy of Baden and settled at Seignelay, in the Yonne, as a land surveyor, and his great-grandfather was the manager of the gun factory at Saint-Etienne under Napoleon I.

His grandfather established an engineer's workshop at Roanne, afterwards carried on by his father, and subsequently relinquished when he came to Paris, where the present Tenting was born; the

latter, after occupying the position of foreman of M. Dalifol's works, where carriage-building had given him a turn for the study of auto-locomotion, opened his own premises in the Rue Curial in 1884.

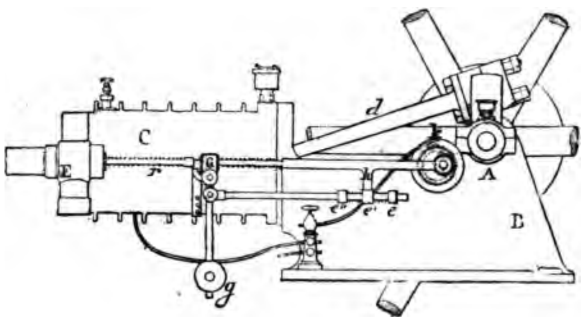


FIG. 56.—Tenting's Motor, elevation. (G. R.)

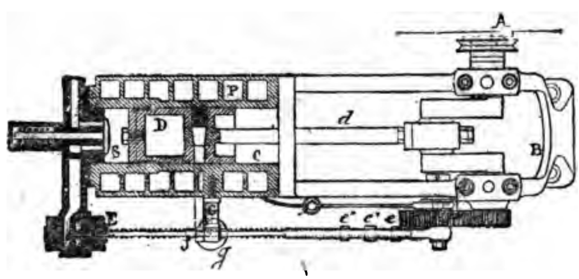


FIG. 57.—Plan. (R.G.)

Here it was that in 1887 Tenting invented the gas-engine, which is still one of the simplest and best in existence, and in which neither solidity nor safe working have been overlooked.

Tenting's engine, shown in Figs. 56 and 57, is a

horizontal one: the cylinder (C) is in the same casting as the frame (B), carrying the bearings of the shaft (A), driven by the connecting-rod (*d*), which is connected with the piston (D).

These bearings are slightly raised so that the axis of the shaft (A) is placed above the axis of the cylinder (C); consequently, when the piston (D) is at the end of its stroke, that is at the moment of ignition, the connecting-rod (*d*) is slightly inclined out of the horizontal, just beyond dead point, a circumstance which is favourable to rapid expansion.

Ignition is obtained by interrupting the circuit of a Ruhmkorff coil at *k*, but M. Tenting also ignites by means of an incandescent tube.

The lateral compartments (P) are also in the same casting as the cylinder (C) and the frame (B), and they form a grooved compartment in which the air circulates according to the difference of its temperature, so as to properly cool the cylinder.

The throttle-valve is placed at S in the centre at the bottom of the cylinder; it opens automatically by suction, directed towards the centre, and then the gas or the petroleum vapour enters through the round holes near the centre, while the air enters through another round hole of larger diameter.

The burnt gases are expelled through the valve E; the spring-rod (*r*) which governs this valve is actuated by an eccentric driven by a gear-wheel keyed on to the shaft (A), so arranged as to move

it only once in every second revolution. This rod (*r*) is fitted with an arm (*h*), and this, by means of the spring thrust-piece (*e e′ e″*), acts on the stem of a pendulum governor (G *g*). When the speed becomes excessive, the small arm of this pendulum interposes itself between the fixed collar (G) and the thrust-piece (J), so that the escape-valve cannot close; in this way there can be no suction through the valve (S), and the piston (D) runs freely in the cylinder (C), until the reduced speed enables the working parts to resume their normal action. This we see is the reverse of what happens in the Daimler Motor, in which the escape-valve is kept shut until speed is slackened. At any rate, the substantial build of Tenting's engine, its smooth working, and the cooling being effected without water circulation, renders it very well adapted for driving auto-cars.

The first auto-car that came out of Tenting's works in the Rue Curial at the beginning of 1891 is shown in elevation and plan respectively in Figs. 58 and 59.

It is driven by the motor we have just described, coupled with a carburator (*e*) for preparing the hydro-carburet vapours contained in the reservoir (E), which are essential for the detonating compound.

By means of these simple arrangements, and working at a high temperature, Tenting has obtained some remarkable results in the way of consumption; working at normal speed he has brought his consumption down to from 7 to 9

ounces of petroleum per H.P. and per hour. At any rate this is what was shown in the trials made

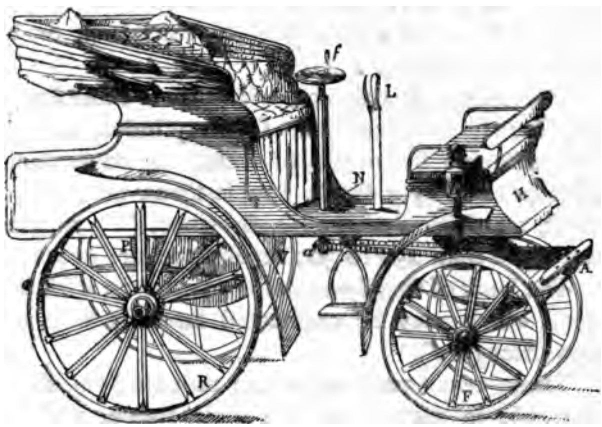


FIG. 58.—Elevation. (Fr. A.)

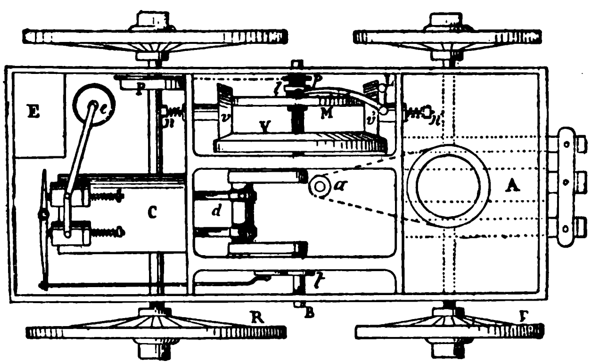


FIG. 59.—Plan. (Fr. A.)

by the artillery and engineering officers at the Central Electric and Telephone Station. The

French War Office has, in fact, up to the present time purchased from M. Tenting twenty-eight engines of 4 H.P. each for its own use. The ignition may be effected either by electricity or by incandescent tube.

The motor in this car, which is a cabriolet to seat four persons, consists of two cylinders coupled in a common frame (C), of which the connecting-rods (*d*) act by a single double-throw crank on a shaft, to which is keyed a fly-wheel (V), making not more than 250 to 300 revolutions per minute.

The back of this fly-wheel is adapted to a friction cone, which may be connected laterally with the two discs (*v v′*).

These two small cones are mounted on shafts movable in sockets on the main frame, and are continually forced against the fly-wheel (V) by suitable springs placed at *n n′*.

Another disc (M) revolves in a plane parallel to the plane of V on a loose shaft on the two-throw crank shaft, having the same axle, and supported at another portion in a plummer block secured to the frame; it derives its motion by the friction on the surface of the discs (*v v′*), and imparts it to the pinion (*p*), and this, by means of the chain (*p* P), works the pulley (P) fixed on to the differential gear-box placed on the driving-shaft of the rear wheels (R).

The transmission of the motion to the shaft by friction, by means of the disc M, is very ingenious, and at the same time very practical. A system of gearing, worked by the lever L,

enables the driver to alter the position of the disc M as regards the common axle of the discs *v v'*, so as thereby to alter the speed gradually, and avoid the unpleasant shocks always caused by throwing wheels into gear. When the disc M is brought near the axle of the discs *v v'* the speed slackens: when this axle is in the plane of the disc M the speed becomes *nil*, and when the same disc passes to the other side of this axle, then the direction is altered; that is to say, that a backward speed can be obtained rapidly, easily, and without any shock.

By means of a pedal (N) placed at the bottom of the carriage (Fig. 58), and a system of special levers, the driver has full control of the ends (*n n'*) of the disc axles (*v v'*), and may throw these discs out simultaneously, so as to disconnect them from the disc V. In this way the transmission of power to the axle of the wheels (R) can be arrested without stopping the motor.

In a word, the car can be brought to a standstill in three ways—

(1) By bringing the box (M) to the centre of discs *v v'* (speed *nil*).

(2) By disengaging the discs *v v'* as above stated.

(3) By shutting off the cock leading from the passage, whence the petroleum vapours pass from the carburator (*e*) to the cylinders (C).

A brake acting on the differential box (P) facilitates these manipulations.

The engine is started by a crank applied at B,

at the end of the double-throw crank opposite the disc V.

The cylinders are enveloped in a casing within which a regular circulation of water, stored in the tank (H), enables the temperature of the cylinders to be lowered, but not to such a degree as in the case of other motors. In this consists the whole secret of the economical working of the Tenting engine; yet this rise in temperature would not be effected were it not for the simple and substantial construction of the motor.

The first motor-car built by Tenting (Fig. 58) was fitted with a fore-carriage (A), which turned on a bolster-pin and rested on springs over the front wheels as in ordinary carriages. For steering purposes there is a hand-wheel (*f*) placed within reach of the driver, giving him control over this fore-carriage by means of a pinion (*a*) connected with a gear-wheel by a chain, the bolster-pin being the axle of this wheel.

Tenting's Second Auto-car: a phaeton to carry six persons. Mr. Tenting, however, soon recognized, to his cost, that this system was inadequate, and he was not long in adopting Bollée's steering system of coupled pivots, as shown in elevation, plan, front and back views, in Figs. 60, 61, 62, and 63, of this the latest auto-car turned out of Tenting's works.

The principal modification at once apparent in Figs. 60, 61, and 62, consists in the arrangement of the two driving cylinders (C C′) in the same vertical plan, placed over one another, and coupled

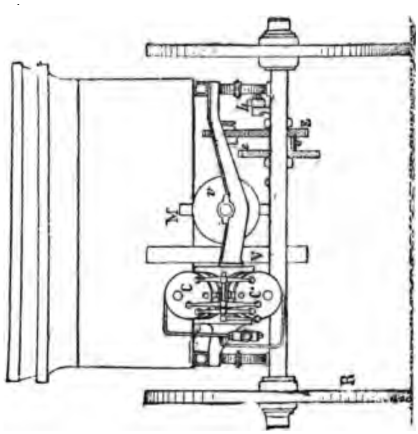


FIG. 60.
Front View of Tenting's Second Auto-Car Phaeton to seat six persons. (Fr. A.)

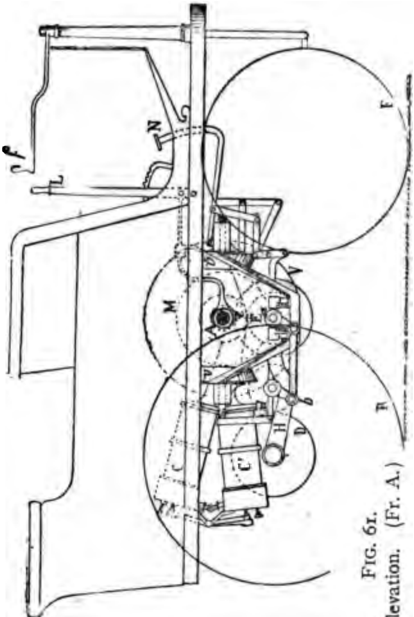


FIG. 61.
Elevation. (Fr. A.)

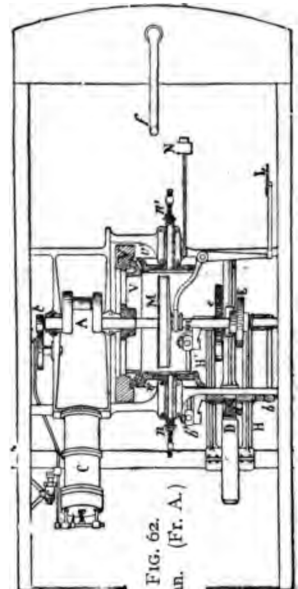


FIG. 62.
Plan. (Fr. A.)

so that the piston-rods attack the centre-bit of the shaft (A) by means of one single piston-head.

These cylinders will act either with gasoline, refined petroleum, or lamp petroleum, and without the carburator. The petroleum is injected by a small pump (*c*) at the end-plate of each cylinder, which forms a vaporiser. A circulation of water is maintained round each of the cylinders (C C′), both of which combined will develop from 6 to 8 H.P. The transmission of the motion of the shaft (A) is effected, as we have explained, by means of the fly-wheel V to the discs *v v′*, and by friction to the central disc M: here again another improvement is the fact of dispensing with the chain.

Two gear wheels (*e* and E), adapted for changing the speed to suit level runs or gradients, transmit the movement of the shaft (A) to another shaft (*a*) placed below. The latter, resting in two plummer blocks, connected to the carriage-frame over the springs, acts as a support for the ends of the two branches (H H′) of a draw-bar, the other two ends of which are carried by the driving-axle, on which they can oscillate by gentle friction. The differential is fixed at D between these two branches, so as to act on the rear wheels (R) in the usual way.

The spur-wheel of this box is not connected by a chain, but by a spur-pinion (*d*), the axle of which, as it revolves in the bearings carried by the branches (H H′), is driven at each end by two cranks (*b b′*), moved in their turn by two sym-

metrical connecting rods set in motion at the opposite extremity by similar cranks keyed on to the shaft (*a*).

Therefore it is chainless, and when owing to the elasticity of the suspension springs the axle *a* becomes displaced in relation to the axle R, which is fixed, the draw-bar (H H′) turns round this axle, and the pinion *d* revolves on D, while

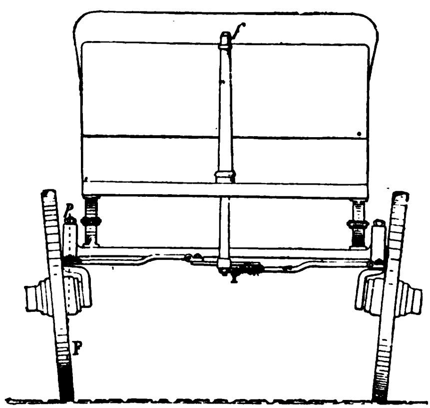


FIG. 63.—Front View. (Fr. A.)

continuously imparting to it the motion of the shaft *a*.

Here again in this car we have the lever (L), working as above described, controlling the speed and the backward or forward motion by altering the positions of the discs (M), and also we have the pedal (N) acting, by means of a system of levers shown in Fig. 61, on the extremities (*n n*′) of the disc-axles (*v v*′).

The car is steered by the lever (*f*) and the connecting rods (P) on the independent pivots (*p*) of the front wheels (F), provided, however, with this special arrangement, that the vertical axle of the pivot (*p*) exactly passes the contact point of the tyre of the wheel (F) with the ground. Hence the revolutions are devoid of shocks, free from all those side motions which, in most steering arrangements of this kind, arise from the fact that the points of contact of the wheels (F) describe circles on the ground, round the pivots (*p*).

Most of these improvements have been adapted to the first cabriolet (Figs. 58 and 59), which is now a very comfortable vehicle, set on four pneumatic wheels, and capable of running at a speed of 20 kilometres (12½ miles) an hour, while the occupants feel no more vibration than if they were sitting quietly in a boat.

Quite recently some one threw himself under the car when M. Tenting was driving; the two pneumatic wheels passed over the man's legs, but he sustained no hurt beyond a slight feverishness resulting chiefly from the shock inseparable from an accident of this kind.

In running order and carrying four passengers, this vehicle weighs 1500 kilos. (1½ tons), two-thirds of the weight being on the rear axle; so that here there were 500 kilos. (10 cwt.), which had they rested on metal tyres would certainly have crushed the victim's limbs. In addition to the rest, here is another unexpected advantage of the use of pneumatic tyres.

To start the car, the carburetted air inlet cock is opened, then with the aid of the crank two or three turns are given to the fly-wheel in the direction desired, and the motor begins to work of itself; then the driver mounts the box, and puts the reversing lever into the first notch of the advance; he next presses the treadle which acts on the gear, and the vehicle starts off at once without any vibration. The driver then puts the lever to the required speed.

To stop the car, the driver lifts his foot off the gear pedal and places it on the brake pedal, when the car stops, although the engine continues to work. If it be desired to keep the car at a standstill, the carburetted air inlet valve, which is within reach of the driver, must be shut off.

The transition from one speed to another is effected without any vibration by means of the reversing gear to the right of the driver.

Running on a good dry road these cars will ascend gradients of 8 to 10 per 100.

M. Tenting is now building an omnibus to carry twenty-six passengers, worked by a motor with four cylinders, and capable of developing 16 H.P. maximum.

Here indeed are means amply sufficient to meet every desideratum in motor-cars, and to render them practicable in every respect; as we have stated, gratifying is it that there is nothing in them which has been borrowed from foreign inventors; this car is exclusively and entirely French.

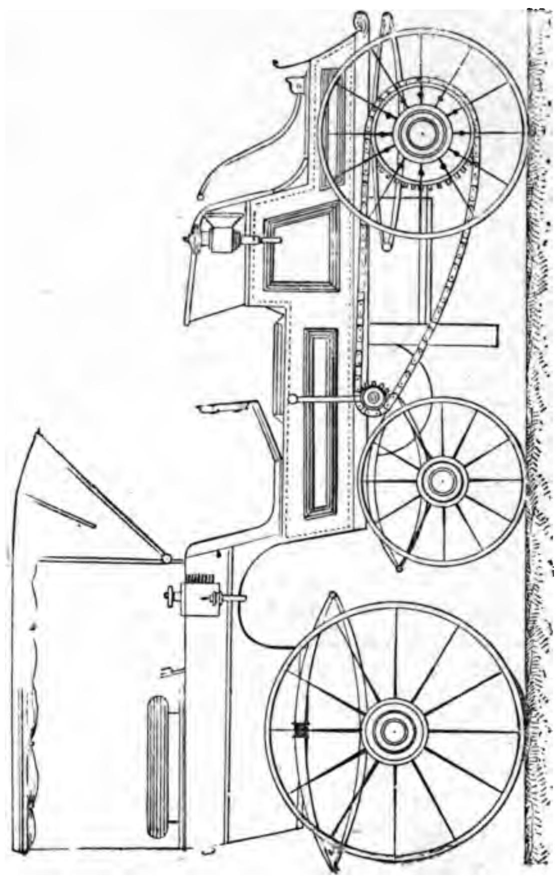


FIG. 64.—Lepape's First Auto-car, Locomotive Type. (L. A.)

CHAPTER XIV

LEPAPE'S MOTORS—LEPAPE'S AUTO-CARS

LEPAPE'S Motor is the corollary of the same idea that inspired the inventor of the mechanism of the Brotherhood steam-engine: like this, it consists of three cylinders radiating round one shaft, their axles being in the same perpendicular plan as the shaft, and lying one above the other at an angle of 120°.

This motor, which works very steadily, has been most ingeniously devised for the purpose of driving an auto-car; it weighs 240 kilogs. (4¾ cwts.), and develops 6 H.P., viz. 40 kilogs. (88⅔ lbs.) per H.P., without the fly-wheel; but the fly-wheel forms a portion of the transmission gear to the wheels, as we shall presently see. The petroleum consumption is three litres (5¼ pints) per hour.

The carburator, in which the petroleum essence, weight 700 to 720 grammes per litre (7 to 7⅛ lbs. per gallon), is vaporized, is heated by water which has circulated round the cylinders, and been returned to the cistern by a centrifugal pump, passing on its way through a cooling apparatus.

Fig. 65 shows one of the cylinders (C), which

consists of a detonating motor acting directly in four cycles (type B, b^2) (page 18). The hollow piston (D) is jointed directly on the connecting rod (*d*), and the three connecting rods (*d d'* etc.) are jointed on the same journal of the double-throw crank (A) that carries the fly-wheel.

The boxes of the valves (S *s*) are cast in one

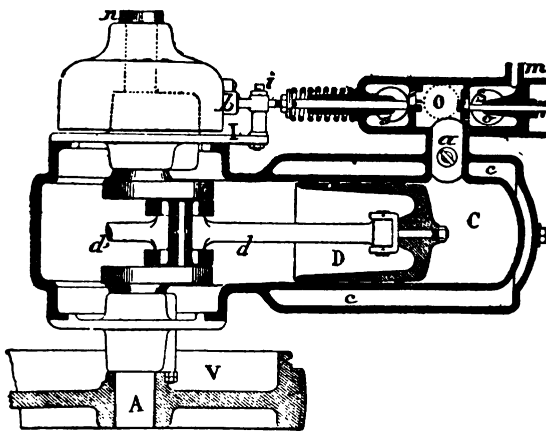


FIG. 65.—Lepape's Motor. (L. A.)

piece with the cylinder, around which a double casing forms an annular space for the circulation of the cooling water; a single tube (O), behind this pair, connects the pipes of both valves and discharges freely on the outside, where it serves alternately for drawing in the air necessary for the detonating compound, and for throwing off the residues of the explosion.

When the starting crank fitted at N is properly turned, that one of the three pistons which is at the end of its stroke draws in, through the valve S, the carburetted vapours at *m*, and the air at *o*, so as to form the explosive compound; as soon as this piston starts its backward stroke, the valve (S) closes, compression ensues, then explosion, and afterwards the next forward stroke.

At the very moment when the fourth cycle commences, and the piston moves backwards to drive out the residual gases, a cam (*b*) projecting from a bronze boss presses on the finger (*i*), and this raises the valve (*s*). This boss revolves loosely on the shaft (A) at such a reduced speed that the rod (I) fixed to the shaft catches into the cam (*b*) at a point calculated to raise the tail-pieces of the valve (*s*) of each cylinder with the finger (*i*), so as to cause the evacuation of the residues at the right moment.

Electric ignition takes place in the hollow plug (*a*), in the interior of which there is an insulated copper needle, and a wormed stem that can be regulated by screwing it on a bridge spanning the diameter of the plug; the spark passes between points which are about one millimetre (one-twenty-fifth of an inch) apart.

Lepape's First Auto-car. Locomotive Type.—The first car built by Lepape with this motor was a kind of brake to seat four or five persons, fitted with two seats placed parallel to the axles, one behind the other, but by removing the rear seat, as shown in Fig. 64, the fore-carriage of any four-

wheeled vehicle (in the present instance a small spring-van) could be substituted.

We will not here repass judgment on this eminently defective system, the responsibility for which we must leave to M. de Dion, the inventor, but we will examine Lepape's auto-car as an auto-break fitted with two seats.

The leading feature of this vehicle is that the front axle is the driving one—an excellent arrangement, desirable in every respect; true, it is steered by the rear wheels, which arrangement is less worthy of commendation. M. Lepape was not bold enough to abolish at a stroke all hitherto accepted ideas by making his front axle a steerer and a driver at the same time. He is a reformer only by halves.

The ignition in this case is produced, as we have stated, in each cylinder by electricity, and the cooling is effected by water circulation constantly maintained between the cylinder and a very ingenious surface cooler, worked by a centrifugal pump driven by friction, and assisted by a small disc on the plate (V).

The water-tanks, as also the petroleum-tank, the carburator, the cylinders, and all the working parts, resting on the front driving axle, give the latter ample adherence.

The system, however, of transmission by direct friction between the vertical fly-wheel (V) of the three-cylinder motor (M) (Fig. 66) and the vertical disc (P), keyed on the countershaft which carries the differential (D), is both simple and convenient.

The section of this shaft at A is square; on it is shifted the socket that carries the disc (P) by manipulating (from the car) a lever that works right or left, by the small chain (C) or by the one opposite to it. This countershaft has a bevel-wheel at each end, and this wheel, by means of the chain

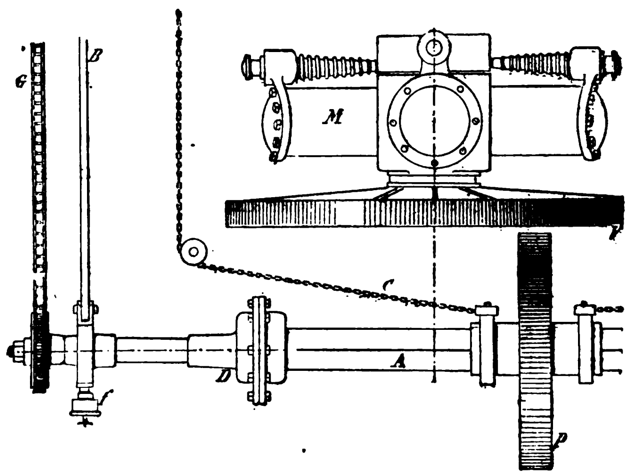


FIG. 66.—Lepape's Transmission Gear. (L. A.)

(G), communicates the motion to the hub of the corresponding front wheel.

Two connecting-rods (B) are used for disengaging the gear by separating the disc P from V; if this separation extends to a certain distance, the disc (P) rubs against a fixed transverse bar, making it act as a brake, without, however, inter-

fering with a supplementary brake worked by a treadle.

It will be understood that, according to the displacements of the disc (P) on the surface of V, any possible speed can be obtained; even negative speeds if P is passed over to the other side of the centre of V.

Lepape's second auto-car, shown in Fig. 67 in perspective, and in Fig. 68 in front view, is a light, handsome, natty vehicle for two persons, the front wheels being drivers, and the rear steerers.

The body of the car rests on a carriage consisting of two curved iron beams, the ends of which are attached to the front and rear axles; it is made up of two distinct parts.

1. The car, with its well-upholstered seat, is hung on two clutch springs placed under the seat, and on a third tranverse spring just under the foot-board, the whole weight thus being over the back portion of the beams.

2. The motor fixed in front direct on the beams; there is no communication between the car proper and the machinery; they are absolutely self-contained. The levers and other working parts (L, *l*, *s*, *h*) are within reach of the passenger, but do not touch the car, as they are simply fixed to the motor portion.

This latter is not hung; it is so substantial that the elasticity of the pneumatics on the front driving-wheels should be sufficient to prevent any serious wear. This arrangement has the advantage of quite dispensing with the chain.

The motive power is produced by a single cylinder (C), which causes the axle (A) of the horizontal fly-wheel plate (Fig. 68) to revolve at the rate of 300 revolutions.

The petroleum in the reservoir (*c*) passes through a carburator before going into the cylinder through the cock enclosed in the valve-case (S), worked by means of the handle (*s*) conveniently placed within reach of the driver.

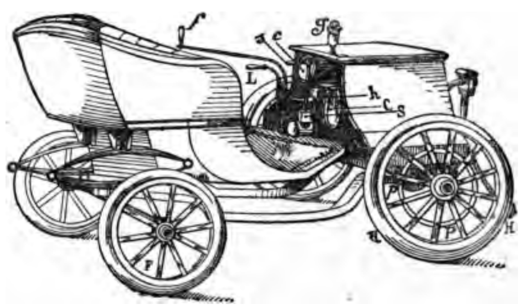


FIG. 67.—Lepape's Second Auto-car. (Fr. A.)

Within equally easy reach there is also a lever (*f*) which acts on the loose rear steering-wheels (F) mounted on independent pivots; and, again, a second lever (L) for altering the speeds of the transmission by friction.

The fore portion is covered by a neat japanned hood, above which is seen the sight-feed lubricator (*g*).

Only one of the wheels in the vehicle we are describing is a driving-wheel, the driving being

effected by a gearing (P) fixed on to the spokes of the wheel (R), and carried by the bevel-wheel (*p*); this bevel-wheel is so arranged that the direction of the motion of the wheel (R) tends to raise it, thereby increasing the adherence of the friction-roller (*v*) to the disc (V).

The single driving-wheel is ample to drive the vehicle. Nothing would be simpler, however, than to have the second wheel under command in the same way by having a differential on the same shaft as *v*.

Fig. 68 gives an end view of the car. The disc (V) fitted on to the shaft (A) of the motor is in contact with the friction-roller (*v*), mounted on a square shaft, which, however, is rounded at the ends to form journals, so that they may turn in the bearings (*r r'*); these bearings rest on the ends of two crank levers (*r* O *n*, *r'* O *n'*), jointed to the fixed axle of the front wheels (R), and are set in motion by the rod (*n n'*), so that if this rod is pushed forward by means of a pedal, the catch (*v*) of the disc (V) is disengaged, and if this action is continued, the brake (H) is made to act on the front driving-wheels (R). Lastly, if it be desired to keep the brake gear in action, without having to keep the foot on the pedal, the brake can be locked with an ordinary screw arrangement, the handle to which is at *h* close to the driver.

The small collar (*l*) can be so worked with the lever (L) as to make the roller (*v*) glide along the square axle, and according as the roller is brought near to or moved away from the axle (V), the

speed varies, while a negative speed can be obtained, that is to say, when the centre of the disc (V) is passed, we get speed in the opposite direction.

Whatever it may be worth, this mechanism, as shown in Fig. 68, only weighs 300 kilogs. (6 cwts.) in running order, and when carrying two passengers

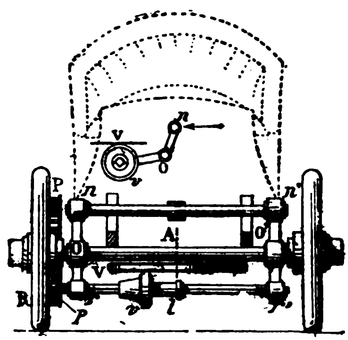


FIG. 68.—Lepape's Second Auto-car, End View. (Fr. A.)

it will make from 16 to 18 kilometres (10 to 11 miles) per hour, the motion being very smooth, thanks to the pneumatic tyres on all four wheels, for M. Lepape is a strong advocate both for pneumatic tyres and for wooden wheels.

CHAPTER XV

AMÉDÉE BOLLÉE'S QUADRICYCLE CAR

THE "LÉO" AUTO-CAR

BOLLÉE is a name associated with mechanical engineering from time immemorial; there is quite a dynasty of Bollées, all genuine and intelligent workers; the grandfather of the present Bollée, whom we will describe as Amédée I., he being the founder of the dynasty, though his Christian name was in reality Ernest; then his three sons, Amédée, Ernest, and Auguste, and afterwards his three grandsons, Amédée, Léon, and Camille.

The first Bollée was unfortunately killed by a runaway horse, so that now there are but seven Bollées, "a goodly crew," as was remarked in a letter we received from M. Amédée Bollée, senior, who was working night and day to finish the cars which were to take part in the Paris to Marseilles race.

Amédée I. (or Ernest if you will) opened a bell-foundry at Mans in 1842; this grew to be the leading one of our day, and from it have come

most of the famous peals of bells used in France and abroad. He was the inventor of the Bollée "Ram," and of the *Eolienne* Wind Motor. In 1880 he was decorated with the Legion of Honour. He has assisted in all the works undertaken by his son.

Amédée II., who even in the lifetime of his father occupied the position of manager of the factory, is now universally regarded as the reviver of auto-locomotion, to the development of which he has largely contributed by his remarkable inventions, and particularly by the invention of Bollée's steering apparatus with independent jointed pivots, patented on April 28, 1873.

He was the genuine and only precursor of our great auto-locomotion movement; he sowed the seed and tended the plant, the flowers of which are budding so radiantly to-day.

Amédée III., whose brand-new car entered for the Marseilles trip, was patented on January 27, 1896 (253,437), took command of the works two years ago, and has managed them ever since under the watchful eye of his father.

This car, shown in elevation in Fig. 69 and in plan in Fig. 70, is notable in two respects; it dispenses with the driving chains, at the same time it imparts to the driving-wheels, without in any way affecting the mechanism, the "dishing" customary in carriage-building.

The whole of the machinery, simplified to the utmost, is so arranged that it can be easily inspected from either end of the car; yet there is never any

necessity for the passenger to lift the trap-doors of the foot-board to look below.

The double-cylinder horizontal motor (C), all in

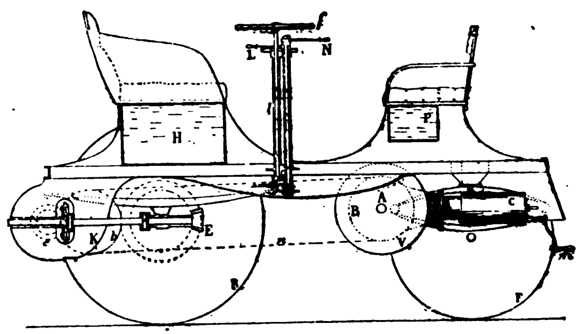


FIG. 69.—The Amédée Bollée Car, elevation.

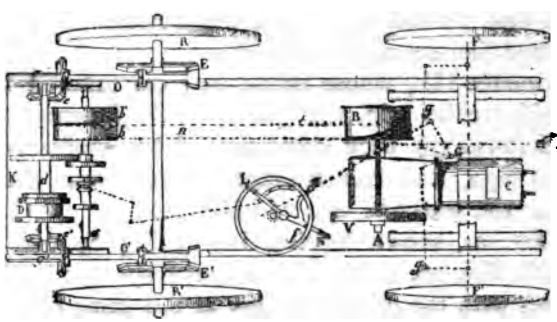


FIG. 70.—Plan.

one casting, acts in four cycles, and presents no special feature; the pistons work alternately, so that there is one explosion for each revolution of the engine.

The cooling process is effected by vaporization of the water, without any return to the cistern, which remains cold; the water runs freely round the cylinders owing to the difference in the level.

The engine is started with the handle (*m*); this is turned round two or three times, and the engine starts at an ordinary speed; should the normal speed be exceeded, the governor will prevent the closing of the throw-off valves. The single crank shaft (A) revolves; at one end of this shaft there is a fly-wheel (V), and on the other there is a drum (B), and this by means of a belt (*n*) transmits the movement to the counter-shaft (*a*), which carries the fast pulley (*b*) and the loose pulley (*b'*). This shaft, running parallel to the axles, is connected, by means of four gear-wheels, to four bevel-wheels keyed on to the shaft (*d*), on which runs the differential (D); according to the movement of the shaft (*a*) imparted to the gear-wheels, one or other of the four bevel-wheels is brought into play, and four different speeds may be obtained.

At each end of the shaft (*d*) there are bevel-wheels which gear at *e e'*, into two similar wheels bevelled at an angle of 45 degrees, and running loose on their horizontal axes (*o o'*).

All the machinery (engine, pulleys, and shafts *a* and *d*) is fixed to the frame (the latter by the brackets K), hung on the axles by four springs seen in Fig. 69.

The jointed gear which takes the place of the chains for connecting the shaft of the differential gear with the axle of the rear driving-wheels

(R R′) in order to obviate the vibrations of the springs, is formed by two longitudinal shafts (O O′) with articulated swivel joints controlling two pinions, which turn loose in two sockets formed at the ends of the rear axle, and gear into two bevel-wheels at E E′, which are keyed on to the naves of the driving-wheels (R R′); these latter revolve loosely on the journals at the ends of the fixed axle.

The steering apparatus is compactly grouped between the two seats facing each other: first of all the hand-wheel (*f*), which by means of a rack and pinion causes the spindle (G) to revolve, and this by means of the connecting-rods (*g g′*) imparts the required motion to the independent pivots of the front steering-wheels (F F′).

Next the lever (L) for shifting the gearing on the shaft (*a*), and another lever (N), which can be made to shift the belt (*n*) on to the loose pulley, so as to throw the driving-wheels (R R′) out of gear.

The frame and the driving gear are arranged so that they can be adapted to any description of auto-car, large or small, whether worked by steam, petroleum, or electricity. The whole arrangement is designed with a view to lower the centre of gravity as much as possible, and to permit the position of the steering levers to be altered to suit any style of vehicles. In this particular case, where the car is made to seat four persons facing each other, the petroleum-tank is placed at P, under the front seat, the cooling water-tank is under the opposite seat at H.

The first car of this kind, which is now in Paris, has already made a run of 700 kilometres (430 miles), and there is every reason to believe that it will give a good account of itself in the Paris-Marseilles trip.

Thus we find that the Bollées in the third generation renounce the use of steam-power, though it was by its application that Amédée II. made his name.

THE "LÉO" AUTO-CAR.

Léo Auto-cars is the title which M. Léon Lefebvre has chosen for his petroleum-cars.

FIG. 71.—The Léo Car.

Fig. 71 represents a dog-cart to seat four persons sitting back to back; the rear wheels are drivers, and the front wheels are steerers with two pivots.

The motor is of the Pigmy type, with two coupled cylinders as shown in Fig. 72, but when fitted on the car for greater convenience in fixing and for the purpose of reducing the vibrations, it is placed horizontally under the front seat, the cylinders facing the front of the car in the position shown in

FIG. 72.—Pigmy Motor fixed vertically.

vertical section in Fig. 73 and in horizontal section in Fig. 74.

Léon Lefebvre's car is elegant in appearance; this is more than can be said of many auto-cars, which are for the most part heavy-looking and ungainly. In the Léo car the carriage-work has been very carefully turned out by one of the leading Paris firms.

The main feature of the Pigmy motor is its symplicity. M. Lefebvre builds this motor in several

designs according to requirements, suitable for consuming ordinary lighting-gas, refined essences or lamp-petroleum; the only modification necessary is to alter the distributing and ignition arrangements.

To these various advantages the Léo Lefebvre motor adds another, namely, a decrease in weight: the 3 H.P. only weighs 80 kilos. ($1\frac{1}{2}$ cwts.), and the 6 H.P. only 140 kilos. ($2\frac{3}{4}$ cwts.).

The horizontal position of the motor does away with the intolerable vibration experienced in cars in which the motors are placed vertically, or in which the shaft is slightly inclined to the vertical.

The motor is bolted at P and P′ to a strong iron beam attached to the frame, and supported by a collar which also connects the cylinder heads to the car under the front seat.

Figs. 73 and 74 show an apparatus worked by the ordinary petroleum essence of commerce, weighing 700 to 720 grammes per litre (7 to $7\frac{1}{8}$ lbs. per gallon).

In each of the cylinders (C) there runs a piston (B), the connecting-rod of which is attached to the two cranks, placed at an angle of 180 degrees, of a double crank which forms a part of the main shaft (A). At one end of this is the fly-wheel (V), and the other drives the gear (*e* E) which works the distributing valve cam (O). The motor acts in four cycles, the ignition being effected by a vaporizer which is heated to a dark red heat.

Air is introduced by suction through the valve D regulated by a spring, while the petroleum vapour passes through the orifice *d*.

After the compression (second stage), the ignition and the stroke of the piston (third stage), the burnt

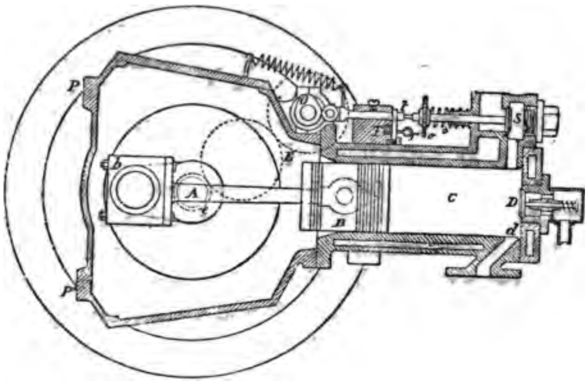


FIG. 73.—Vertical Longitudinal Section.

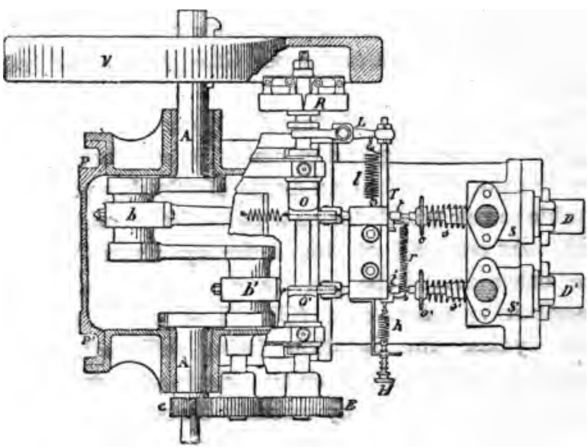


FIG. 74.—Plan.

gases are expelled through the valve (S), held in its seating by the spring *s*, and raised at the proper moment by the play of the cam (O). The cycle is regulated by the milled nut (*o*).

Regulating is effected in a most simple way by acting on this exhaust-valve (S).

A centrifugal governor (R), lodged in the fly-wheel (V), works by means of lever L the rod T, which is guided and brought back to its position by a spring (*l*); on this rod there are two tappets (*t t'*), joined together by means of the spring (*r*). These tappets at the proper moment place themselves under the stems of valves S S′, so that they may be raised in due course by the movements of cams O O′.

The motor is first regulated, so as to let one single cylinder act, for a normal speed on a level road; if the speed increases (say, for instance, on a slight incline) the governor shifts the rod (T) so that the corresponding tappet (*t*) is not underneath the stem of the valve (S) at the moment when it is required to raise it, consequently no expulsion of the residual gases will take place until the speed has fallen off again to a normal rate. If, on the other hand, the speed falls off (say on a gradient), the rod (T) advances towards the fly-wheel (V), and the second tappet (*t′*) takes up such a position as to work the valve (S), so that the two cylinders act simultaneously, thus producing the maximum of power until the second cylinder is put out of action again.

When the car runs down a steep incline both

cylinders may be put out of action by pulling the knob (H).

The Pigmy Motor appears to us to be admirably suited for its purpose, and M. Léon Lefebvre entered two Léo motor-cars for the Paris to Marseilles run, with the most sanguine hopes of success.

CHAPTER XVI

LANDRY AND BEYROUX MOTOR-CAR

DELAHAYE'S CAR

AMONG the vehicles exhibited as novelties at the Third Cycle Show in December last, there was one which from the moment it was finished attracted attention by the elegance of its form and the gracefulness of its outline. This was the Petroleum-car of Messrs. Landry & Beyroux.

What struck the spectator at the first glance was the evident endeavour on the part of these engineers to produce a vehicle exempt from the clumsy, massive, and unsightly forms one has been accustomed to see in all motor-cars. While most of their colleagues have been content to adopt customary models of cars, such as are in vogue among carriage-builders, and to render these heavier than they were, by the addition of the motor and its appurtenances, these makers have tried to impart to their car an elegant and characteristic appearance, so satisfying to the eye that it should no longer miss the horse in front of the vehicle.

The Landry and Beyroux Car is shown in elevation

in Fig. 75, and in plan in Fig. 76. The vertical Petroleum-motor (C), the oil-tank, the carburator, and the driving gear are carried by a metallic frame (K).

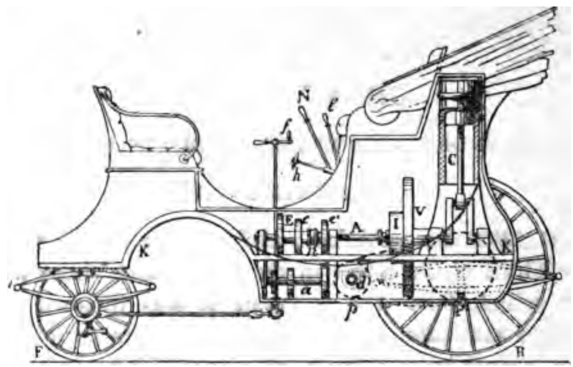


Fig. 75.—Longitudinal Section.

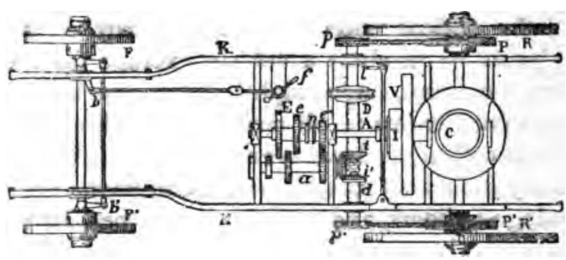


Fig. 76.—Plan.

The same frame may be fitted with carriage-bodies of various forms, but the arrangement of the machinery will be always the same.

The motor (C) drives a shaft (A), on which are

keyed a fly-wheel (V) and a friction coupling (I), which is manipulated by means of the lever (*l*); it carries three gearings (E, *e*, *e'*), which can be made to gear respectively into corresponding pinions, keyed to shaft *a*, and hence permit of varying the speed by shifting a lever (N), which acts on the collar (*n*) of a speed-changing gear.

This same frame also carries the steering gear (*f*), which by means of a rack and two connecting rods (*b b'*) steers the front wheels (F). Both of these have independent pivots.

The shaft (*a*), by means of bevel-gears (*i i'*), transmits the motion to the counter shaft (*d*), which carries the differential gear (D), and to the ends of which the pinions (*p p'*) are keyed; these, by means of two chains, transmit the motion to the gears (P P') keyed respectively to the rear driving-wheels (R R'). Accordingly as the shaft (*d*) of the differential gear (D) is made to gear into the gearing on *a*, either with pinion *i* or with *i'*, the car will travel forward or backward.

By means of a powerful brake, worked by hand from a hand-wheel with screw-spindle (*h*), or which can also be applied most energetically by means of the motor itself, the car can be very readily stopped, even when travelling at a high speed.

But the brake cannot be applied until after the motor has been thrown out of gear.

This arrangement is intelligent and safe, though it involves the use of a good many hand-wheels and levers which the driver is obliged to work in different ways, thus necessitating great attention

on his part; the absence of a convenient grouping of these contrivances constitutes a slight inconvenience, but a still greater one results from the position of the vertical motor at the back of the passengers, immediately above the carriage-springs to which it communicates its vibrations.

Apart from this circumstance the motor, which is of the vertical type, is simple, and acts well; under normal conditions it develops 4 H.P., this being a suitable power for a car seating four persons, facing each other, such as shown in Fig. 75.

DELAHAYE'S CAR

M. Delahaye of Tours has also studied elegance in the outlines of his motor-car—a kind of phaeton, shown in perspective elevation in Fig. 77 and in plan in Fig. 78.

The characteristic feature of the "Delahaye" car is its large wheel-base. ("Wheel-base" is the technical term for the distance between the extreme axles of a vehicle—the larger the wheel-base the greater the stability of the car.)

This is of great importance when the vehicle runs on rough macadam, or on uneven paving. If the axles are too close to each other the car will rock forward and backward or race, and the speed will have to be reduced for fear of serious damage. If, on the other hand, the axles are placed sufficiently far apart the running of the car will remain satisfactory even when running on rather poor roads at a considerable speed.

The frame is made of steel tubes, joined together by cast-steel sockets, brazed on. This construction possesses the advantage of combining great lightness with absolute rigidity and strength.

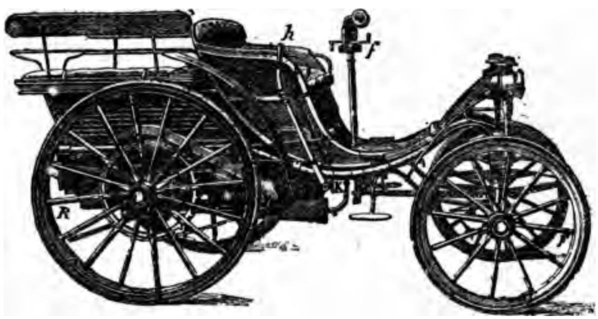


FIG. 77.—General View of the Delahaye Car.

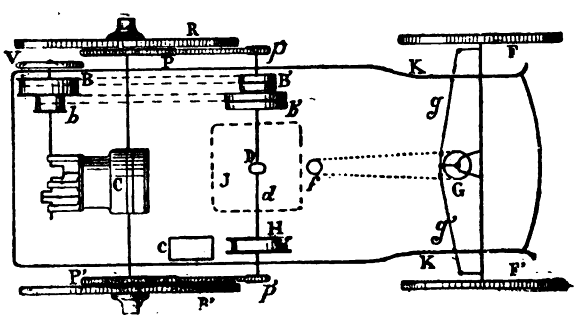


FIG. 78.—Plan.

This frame carries the body of the car, which, according to the requirements, may form a phaeton or a brake, seating four or six persons. The arrangement is such as to permit of using a carriage-body

of any form with the same frame and mechanism, thus constituting different types of cars.

M. Delahaye's motor, invented by himself, and constructed in his workshops at Tours, presents several interesting peculiarities. It is horizontal with two cylinders and balanced pistons, that is to say, the connecting rods are attached to cranks placed at an angle of 180°. Hence results a great regularity of motion, with a *minimum* of vibrations, more especially as the ignition is effected by electricity, and in a most rational manner.

The cranks drive a shaft placed at the back of the car, which transmits its motion by belts, by means of the drums (B *b*), to the parallel shaft (*d*) in front; the latter is fitted with two fixed and two loose pulleys fixed on one side at B′ *b*′; a differential gear (*d*) is mounted in the middle, and lastly, at either end, the shaft has pinions (*p p*′) keyed to it, which by means of two chains act on the gearings (P P′) fixed to the spokes of the driving-wheels (R R′). The hand-wheel (*f*) serves for steering; each steering front wheel (F F′) being pivoted on an independent vertical pivot.

The levers for altering the speed and for working the brakes are combined with the steering apparatus (*f*), so that the driver has close at hand and grouped together all the contrivances for controlling the car, thus reducing his task to a minimum. The two brakes are applied, one to the tyres of the rear wheels (R R′), and the other to a pulley (H), specially keyed to the shaft (*d*) of the differential gear.

The car will attain a speed of 30 kilometres

(19 miles) per hour on a level road with a load of five or six passengers.

The carburator is automatic. It is regulated at the moment of starting, and once regulated it requires no further attention. The ignition is effected by an electric spark, which arrangement permits of varying the point of ignition, as well as the power exerted, by impoverishing the gaseous compound, and affords a means of varying the power to an extent which is extraordinary in a motor of this description.

The cooling of the cylinders is ensured by the circulation of the water contained in the reservoir (J) by means of a small centrifugal pump. This water on issuing from the cylinder jackets passes into a series of pipes placed towards the front of the car, and constituting a surface-cooler which permits of cooling the cylinders with a comparatively small quantity of water.

The normal speed of the motor is 450 revolutions per minute, and it develops up to 5 H.P. The hydrocarburet gas which it employs is obtained from the mineral essence procurable of all dealers, and which weighs about 700 grammes per litre (7 lbs. per gallon).

The car will travel nearly 300 kilometres (186 miles) without replenishing its supplies, and its average speed is 25 kilometres (15½ miles) per hour.

M. Delahaye, who could not get his car ready in time for the Paris to Bordeaux run, entered two cars, a brake and dog-cart, both seating four persons, for the Paris to Marseilles race.

CHAPTER XVII

THE AMERICAN PETROLEUM CARS

DURYEA CAR

THE auto-car race, which took place on November 28, 1895, from Chicago to Waukegan, brought to the fore Mr. Duryea's car, which is shown in elevation in Fig. 79 and in plan in Fig. 80.

The **Duryea Car** presents this peculiarity, that it is driven by a detonating expansive motor, which, in our definitions (page 17), we have marked *a*.

The whole of the machinery and the two seats, placed back to back, rest on a frame supported on the rear axle by two longitudinal springs (T T′), and the forepart of this rests on the steering-wheels (F F′) by means of a transverse spring (*r*); this spring is attached to the frame by a swivel-joint with horizontal pivot, which permits the front axle to assume an oblique position when passing over uneven ground without causing the car to lean sideways.

The Duryea motor, placed in the centre of the frame, is oscillating and double-acting; this

arrangement permits a much more regular action than in the case of direct-acting detonating motors. It is fed with compressed hot gases, at a pressure

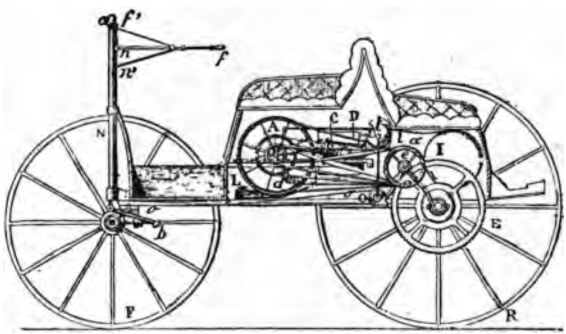


FIG. 79.—Longitudinal Section.

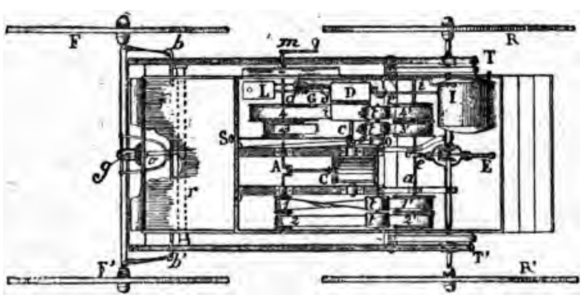


FIG. 80.—Sectional Plan.

of about 8 kilos. per square centimetre (114 lbs. per square inch); these gases are constantly renewed in the generating reservoir (D).

The gazoline stored in the reservoir (I) passes

through a pipe (*i*) into a vaporizer (G), which is heated by a lamp (L). Here the vapours are developed, and pass, owing to their own pressure, into a detonator (*d*) provided with conical orifices into which the outside air rushes at the moment of detonation, to be then forced, together with the gases produced by the explosion, into the reservoir (D).

This air suction answers the double purpose of increasing the volume of gases in the reservoir (D), regulating the pressure and preventing an excessive rise of temperature. This reservoir communicates by means of a pipe (*i'*) with the gazoline reservoir (I), so as to compensate the pressure throughout the system (I G D).

By means of a valve (*s*), arranged on the gazoline feed-tube (*i*), the quantity of gazoline admitted can be properly regulated; this valve when once set regulates the speed of travelling, which, of course, depends on the number of explosions by which the pressure in the reservoir (D) and consequently the consumption of gazoline are increased. The process is analogous to the treatment of the water in the Serpollet boiler. A cock (S) moreover permits of completely shutting off, at will, the pipe (*c*) which distributes the compressed gases in the cylinder (C), so as to stop the motor.

Belt-driving Gear.—By means of a crank the motor works the transverse shaft (A) which carries four pulleys; two of these are of comparatively small diameter (1 and 2), while two more are

of increasing diameters (3 and 4). The three pulleys (2, 3, 4) act by means of belts on three other pulleys, of the same diameter (2′, 3′ and 4′), keyed to the countershaft (*a*).

As regards the pulley 1, it acts by means of a crossed belt on another pulley (1′) of the same diameter, fixed on the same shaft. It will be at once understood that the A group of pulleys (Fig. 79) will produce in the *a* group progressively increasing rates of speed, while pulley 1 will impart to 1′ a moderate backward motion.

To regulate the speed, the steering appliance is shifted, either by raising or lowering it, and fixing it at the desired height by inserting the point (*n*) in one of the slots along the hollow spindle (N); the movement of the arms (*f′ n′*), which run in a groove made in N, draw a small endless cord (*o*), which passes above the tube (N) over a small grooved pulley (*o*), and winds itself, at the other end of its course, on a pulley (O), after passing over two rollers (*g*) which guide it in a horizontal direction. This pulley (O) naturally assumes different positions, according to the course assigned to the cord (*o*), and these positions determine the lowering of one of the four tension-rolls (*t*), which tightens the corresponding belt, thereby causing the shaft (*a*) to revolve at the speed and in the direction required.

If, moreover, the steering appliance (*f*) is turned from left to right, or *vice versâ*, irrespective of the height at which it is set, the car will be made to turn either way, by acting on the pivots of the

steering-wheels (F F'), by means of connecting rods (*b b'*).

The shaft (*a*), which is driven in the manner just described, transmits its revolutions by means of the pinion (*e*) to the gearing (E), which surrounds the differential gear mounted direct on the axle of the rear driving-wheels (R R'). A crank-handle for starting the motor may be fitted at *m*.

The car which took part in the Chicago to Waukegan run, weighed 320 kilos. (6¼ cwts.). Its speed in this trial run was only 7·65 kilometres (4¾ miles) per hour, but we must take into consideration that the roads were at that time covered with snow; on a good dry road it will run up to 32 kilometres (20 miles) per hour.

The motor is capable of developing 4 H.P., and the gazoline reservoir holds 32 litres (7 gallons), which under ordinary circumstances would suffice for a run of 150 kilometres (93 miles). For the distance run in the above-mentioned race, viz. 90 kilometres (56 miles), covered in twelve hours, only 16 litres (3½ gallons) were used. As a matter of fact, however, these figures do not enable us to form any definite conclusion, as we do not know what was the exact power developed by the motor during the period in question.

According to the report by Messrs. Barrett, Lundie and Summers, reproduced at the end of this volume, the performance by the Duryea car was among the best. This is by no means surprising if we consider that this type of motor, combined

with a system of belt transmission, helps to suppress vibrations and jerks.

A Second Car, by Mr. Duryea, recently patented by him in the United States, does not, however, possess these advantages, the engine being a cylinder with direct explosion, and belts having been completely discarded in the driving gear, the transmission being exclusively effected by gearing.

This car has not yet been sufficiently tested to enable us to judge whether this is an improvement —and we doubt whether it is.

These tentative experiments tend to show that the opinions of engineers as regards the standard petroleum car are no more settled across the Atlantic than they are here.

It is to be regretted that Mr. Duryea did not send one of his cars to compete with ours in the run to Marseilles. We presume that we have no more chance of seeing them than the Pennington cars.

These inventors seem afraid of not coming out creditably from such an ordeal.

Can the splendid results we read of in foreign papers be somewhat exaggerated ?

American types of motor-cars, when compared with ours, appear to be somewhat inferior; they bear a certain heterogeneous kind of stamp, and in general appearance are by no means satisfactory, as the reader may judge for himself from the various specimens we quote below.

The "A. J. Pierce" Motocycle (Fig. 81) was one

of the cars entered for the race from Chicago to Waukegan, but it was not ready in time.

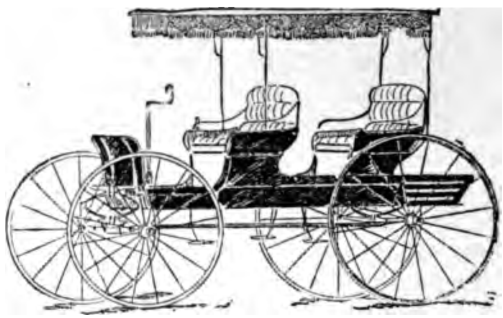


FIG. 81.—The "A. J. Pierce" Motocycle. (L. A.)

FIG. 82.—The "Mac Donnell" Motocycle. (L. A.)

The "P. E. MacDonnell" Pyro-Pneumatic Motocycle (Fig. 82) was also among the entries, but it failed

to make its appearance. Like all American cars, it slightly reminds one of a wading bird; in fact, most of their ordinary vehicles present the same aspect, which fact would seem to indicate that the American standard of beauty in coach-building differs from ours.

The Duryea Car, which carried off the honours in the race of November 28, 1895, is not remarkable for elegance, its general arrangement rendering it rather too suggestive of a spider.

The Friction Car, by Bird of Buffalo (Figs. 83 and 84), may be classed in the same category; it is perched excessively high, and its stability must be proportionately affected.

Certainly for mechanical arrangement it cannot compare with ours. In Chapters XIII. and XIV. we have already described M. Tenting's and M. Lepape's cars, which are likewise provided with friction gears, and our readers need only refer to our description to satisfy themselves at once that the mounting of the friction wheels and their disengaging and speed-changing gear, are simpler and better designed than Mr. Bird's.

The American car is also open to two important objections, viz. the unpleasant vibrations caused by the vertical motor, and the system of steering by means of two twin-wheels pivoted on to a bolster-pin, and these, owing to their proximity to each other, are calculated to impair the general stability of the car even more than the height of the whole construction.

The Vertical Petroleum Motor (C) is supported

towards the centre of the frame; the power is transmitted by a friction disc (V), which at the

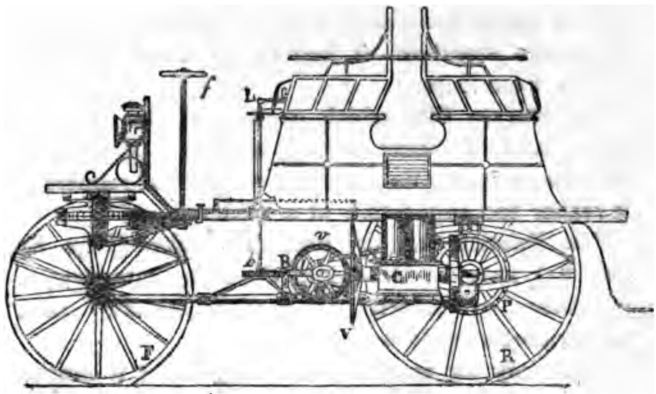


FIG. 83.—The "Bird" Car, elevation. (Fr. A.)

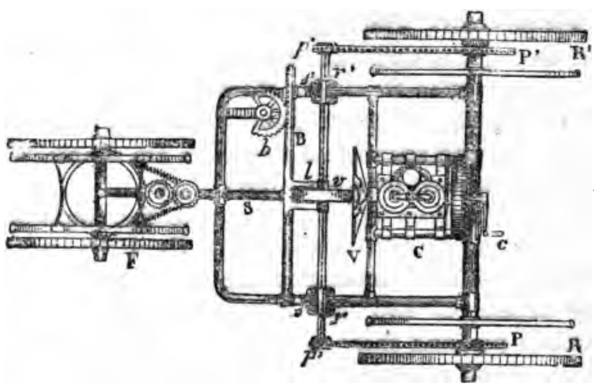


FIG. 84.—The "Bird" Car, plan. (Fr. A.)

same time acts as a fly-wheel, and is directly driven by the motor. A square counter-shaft, mounted

on the frame in the bearings (*r r′*), carries a friction-wheel (*v*), which bears against V.

The transmission of power from this countershaft to the rear driving-wheels (R R′) is effected by a chain at each end, connecting the pinions (*p p′*) with gears (P P′).

The friction-wheel (*v*) can be shifted on the countershaft (*r r′*) by means of a fork (*l*) fixed to a cross-bar (B), which at one end terminates in a rack into which gears a horizontal pinion (*b*), fixed to a vertical spindle; the latter can be moved by the crank-handle (L), placed within easy reach of the driver; this arrangement is fitted with a stop-catch, and by means of a pedal in connection with it the contact between the friction-wheels (V *v*) may be interrupted so as to overcome the resistance of the springs (*s s′*), which push the shaft (*r r′*) against V; to this end the ends of the two arms of the fork are provided with oval apertures.

The steering-wheels (F) are mounted at the end of a kind of carriage-pole (S), on a short axle pivoted on a bolster-pin, so that they can be worked by means of the hand-wheel (*f*), which is within reach of the driver.

The water and gazoline reservoirs, as well as the carburator, are placed under the front and back seats. The motor is started by turning the motor-shaft with a crank-handle (*c*).

That there are many makers of auto-cars in the United States was shown by the eighty-four entries for the Chicago to Waukegan race; this

is also obvious from the fact that among this whole number there were not two entered in the same name. These makers are distributed over a large number of towns throughout the various States: Chicago, New York, Philadelphia, Iowa, Decatur, Owatoma, Kansas City, Columbus, Cleveland, Peoria, Jacksonville, Quincy, New Brighton, Sisterville, Oskosh, Avonia, Hartford, Grand Rapids, Fritchburg, Vincennes, Belleville, Woolverton, etc., etc.; in fact they are to be found everywhere. The city of Chicago alone numbers twenty-nine autocar builders, New York three, Philadelphia two, Iowa three, Decatur two,—yet all this array could muster no more than six petroleum cars for the Chicago to Waukegan race.

CHAPTER XVIII

ACCESSORIES :—LUBRICATORS, BRAKES, PNEUMATICS

AUTO-CAR accessories, or at least some of them, such as burners, lubricators, brakes, and pneumatics, are of great importance.

We have not stopped to describe the accessories peculiar to each of the various vehicles which we have been considering, more especially as these contrivances are in no way connected with the principles on which the working of the mechanism is based, and they might be indiscriminately applied to any car.

Besides, it could scarcely interest the reader to be made acquainted with all the accessory apparatus that might be employed; a single one should suffice by way of specimen for each class; what most concerns the reader is to know which is the best, or one of the best.

Burners.—As regards burners—and these play a preponderant part in the action of explosion motors, ignited by means of an incandescent tube—we have simply described the **Longuemare**, as this system

always gives complete satisfaction, and can be fitted to any motor.

Lubricators constitute another accessory of primary importance; every one knows that the good working of a machine depends on its lubrication, and that its performance will vary considerably according to the more or less efficient system of lubrication.

Now what is true of all machines in general, becomes a matter of vital importance in the case of auto-cars, in which the motors are exposed to all the causes of deterioration and injury to which engines used for industrial purposes are subject, while in addition to these there are the vibrations and shocks sustained while travelling, the dust, etc.

As in the case of the burners, we shall simply describe one system, selecting one that will give complete satisfaction, viz. the **Hamelle** lubricator with multiple outlets,—not indeed because there are no other satisfactory lubricators, but because this one, having been already applied to auto-car systems (Peugeot, Landry and Beyroux, etc.) has invariably acted well—as it is remarkably free from the objections to which gravitation or pin lubricators are open.

The Hamelle Lubricator, shown in longitudinal section in Fig. 86, and in cross-section in Fig. 87, is based on the use of pumps worked by the spindle (A) driven externally by means of a grooved pulley, and lodged in the interior of a box filled with oil, which encloses the whole mechanism.

The discharge of oil from the box through the joint of the spindle (A) is prevented by two felt washers (S, Fig. 85), held in position by a collar (R) and an oval flange (T). An air inlet hole, fitted with metallic gauze, is arranged at one of the upper corners of the box, under the lid. The oil, forced by the pumps, will escape through this hole, and along certain channels, and will invariably and under all conditions find its way into the cavities by means of the tubes in connection with these channels; it will there set up a regular flow

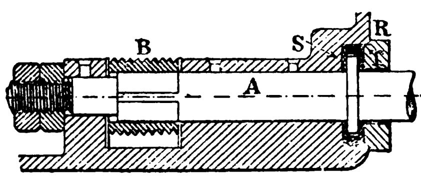


FIG. 85.—Joint of the Lubricator Spindle.

which is sufficient to carry off any impurities, dust, old residues, etc., and rinse them away.

The head of the pump-barrel (N) is fitted with a pressed leather, held in position by the part M, towards the middle of which four lateral holes are pierced for the admission of the oil which fills the box.

The plunger (K), raised automatically by a spiral spring surrounding the cap (M), has its stroke limited by a pin sliding in a groove arranged in this cap. The whole is enclosed in a rose of metallic gauze which serves to filter the oil as it passes through.

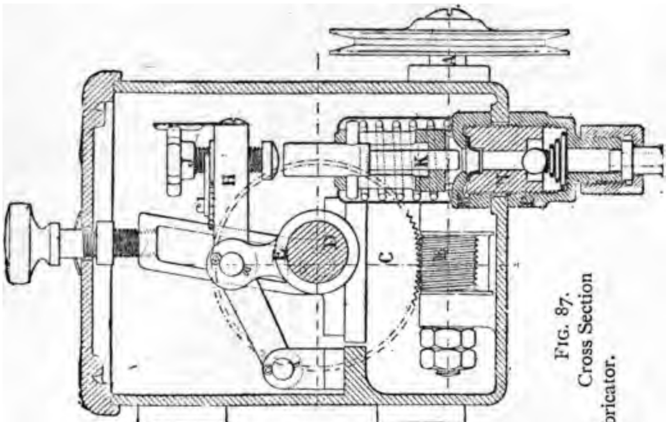


FIG. 87.
Cross Section

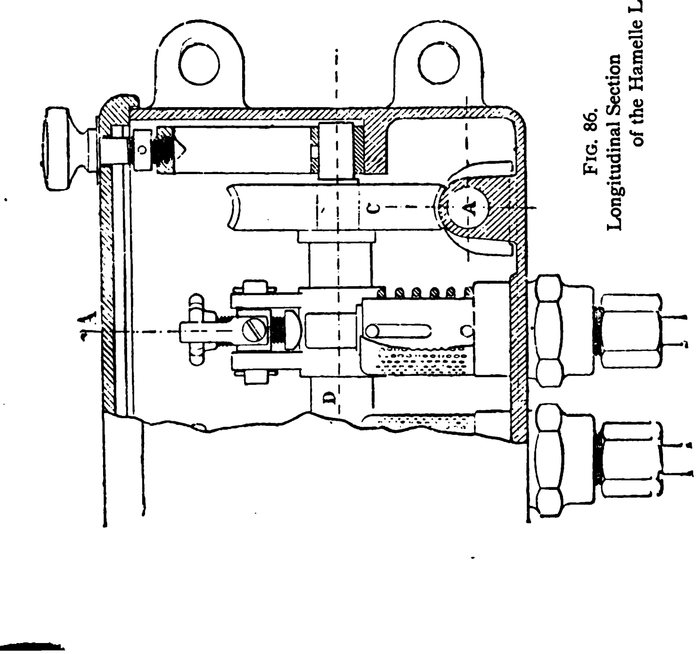


FIG. 86.
Longitudinal Section
of the Hamelle Lubricator.

The spindle (A) transmits its motion by means of an endless screw to wheel (C), and to the eccentric spindle (D), which by means of little links, such as E, sets the lever (H) in motion, to an extent proportioned to the number of outlet holes and pumps in the lubricator.

The action of the lever (H) on the head of piston (K) is effected by means of an adjustable screw (J), so as to limit the output of each pump according to requirement.

The oil, forced into the valve-box (P) by the piston (K), pushes back the spherical valve, the spring then yields under the pressure, and allows the oil to flow out through the discharge channel.

Brakes also in some respects play as important a *rôle* as burners and lubricators. An auto-car must be capable of pulling up within a short distance, no matter at what speed it may be travelling.

The "Lemoine" Brake, which everybody knows, and which on account of its reliable and rapid action has been adopted by the French Artillery, the Army Transport Corps, and the great Omnibus and Tram Companies, no doubt gives satisfaction in cases of this kind, but it lacks the elegance specially insisted on by purchasers of superior and well-built vehicles.

These considerations induced Messrs. Cloos and Schmalzer, who were in a good position to study and appreciate the Lemoine Brake, one of the firm being employed by the Paris Omnibus Company, to devise an arrangement satisfying

all requirements as regards elegance, while at the same time retaining all other desirable qualities.

The "Cloos and Schmalzer" Brake, shown in longitudinal and cross-section in Figs. 88 and 89, is particularly well suited for light vehicles; it will check the wheels instantly without straining the tyres, and in no way interfere with the usual form and arrangement of the nave (*a*), the axle (*e*), or the axle-box (H).

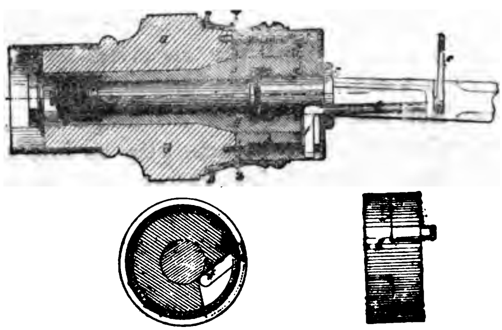


FIG. 88.—Longitudinal Section. (L. A.)
FIG. 89.—Cross Section. (L. A.)
FIG. 90.—(L. A.)

A metallic collar (A), between which and the bush (B) there is an annular space, is fixed by screws (*x y*) to the end of the nave (*a*), and a concentric piece (D) is keyed to the axle (E). A rather thick spring-plate (C, Figs. 89 and 90) is fixed by one of its ends to the cap-piece (D), and by the other to the lever (*f*), joined by a spindle (G) to a rod (F); if this latter is pushed, the elastic ring (C)

opens and its outer periphery, which is faced with brass, becomes firmly forced against the whole circumference of the collar (A).

The action can be modified so as to cause a gradual slackening of speed, or very abruptly applied so as to produce an almost instantaneous stoppage.

Pneumatics throughout.—Wheels must obviously be included among the essential parts of every auto-car. We will not enter into a discussion of the knotty question as to the relative merits of all wooden or all iron wheels; we will confine ourselves to considering the outside tyre to be used for either, and we may say, in this respect, that in view of the perfect results which the use of pneumatic tyres has given in the case of cycles, the opposition offered by certain constructors as well as by some of the most distinguished experts, to the use of pneumatics on the wheels of auto-cars, is quite incomprehensible. It is idle to plead as objections the more considerable load on each wheel and the condition of the roads, seeing that to-day every one knows that Thomson invented the pneumatic tyre in 1845 for the very purpose of applying it to the wheels of ordinary carriages to obviate the excessive jolting on the bad roads in Scotland.

The experiments made by Thomson on March 17, 1845, in Regent's Park, enabled him to demonstrate that the use of his tyres might reduce the effort of traction up to 60 per cent. according to circumstances.

The experiments made last year by Messrs. Barrett, Lundie and Summers with the cars which took part in the Chicago to Waukegan race, enabled them to demonstrate a gain of 65 per cent., thanks to the use of pneumatic tyres.

The solution of the question simply depends on the dimensions, thickness, and strength of the outer covering. Thomson suggested for ordinary carriages, pneumatics about 5 in. in diameter, so inflated as to keep the felloes of the wheel 3 in. from the ground. Well, we can increase these dimensions, if necessary, for a heavier vehicle, but there is no obstacle, either in principle or as regards the material, to prevent the use of pneumatic tyres on the wheels of auto-cars, however heavy they may be.

In fact, there is no lack of makers who hold this opinion; they are not all blind to improvements; we need only quote Messrs. Bouhours, Chicot, Michelin, Vallée, etc., who fit any kind of auto-car with pneumatics strengthened at the surface of impact by a crescent-shaped facing of rubber-cloth, thick enough to render them absolutely puncture-proof.

The only serious objection that can be raised against the use of pneumatics is their high price, but apart from the fact that the costliness of the external covering may be reduced, the price is sure to decrease as the demand increases.

A total abolition of ordinary carriage-springs is moreover quite likely to come about when the pneumatic-tyred car has been sufficiently studied

with a view to combining, in a high degree, the properties of ample width, resistance, and elasticity.

All parts of the car would in this way be subjected to the same oscillations, and the same movements throughout as the axles, and the motor could act on the latter direct by means of ordinary driving gear, thus dispensing with chains.

This would impart greater strength to the whole construction, as well as an actual reduction of the price (for the present carriage-springs are very expensive), and effect besides a marked saving in the amount of motive power required to set the car in motion.

CHAPTER XIX

ACETYLENE—MOISSAN AND WILLSON

ACETYLENE can be obtained direct by producing an electric arc, in an atmosphere of hydrogen between two carbon points, or else by passing electric sparks through vapours of alcohol or ether, or again by decomposing these same vapours in a porcelain tube heated to dull red heat.

It is also obtained by an incomplete combustion of ordinary coal-gas, but these processes are not applicable for industrial uses in the same way as applied by Davy, Woehler, Winkler and Maquenne, which consists in preparing carburets of alcaline or earthy-alcaline metals, which when brought into contact with water disengage acetylene in consequence of the decomposition of carburets, thanks to the great affinity of these metals to oxygen; the hydrogen thus liberated combines with the carbon to form C^2H^2, *i.e.* acetylene.

However, these preparations were exceedingly costly, and little suited for practical use, until M. Henri Moissan, in his paper to the Academy of Sciences (March 5, 1894), set forth a practical process of manufacturing carburet of calcium,

based on the use of certain stated quantities of ingredients.

M. Moissan prepared an intimate mixture of 120 grammes ($4\frac{1}{4}$ oz.) of marble lime with 70 grammes ($2\frac{3}{4}$ oz.) of sugar-charcoal, which he placed in the crucible of his electric furnace, heated for 15 to 20 minutes by means of a current of 350 ampères and 70 volts; the following reaction ensued—

$$Ca\,O + C^3 = C^2\,Ca + CO$$

resulting in the production of from 125 to 150 grammes ($4\frac{1}{2}$ oz. to $5\frac{1}{4}$ oz.) of very pure carburet of calcium.

The process may be worked with a mixture of natural carbonate of lime and any kind of carbon, but the product obtained in that case is more or less impure owing to admixtures of foreign substances.

The substance obtained by M. Moissan in the form of a compact block (moulded in the crucible solely by the powerful action of the considerable source of heat, and without any electrolytic action) is of a blackish colour and insoluble in any re-agent. Its density is = 2·22; when brought into contact with an excess of water it will decompose, this process being accompanied by a liberation of heat, and the products being acetylene and lime, thus—

$$C^2\,Ca + H^2\,O = C^2\,H^2 + Ca\,O.$$

The gas thus obtained has generally a more or less pronounced alliaceous smell, according to the degree of purity of the materials used in the manufacture of the carburet; this is more particularly

the case when operating with carburets of American origin, obtained from a mixture of pulverized chalk and charcoal dust. In this case the yield of acetylene obtained from the carburet is perceptibly less, and an impure gas is obtained, the proportion of which may fall as low as from 150 down to 80 litres per kilog. (2 cub. ft. 700 cub. in., and 1 cub. ft. 500 cub. in. per lb.), while a kilog. (2⅕ lbs.) of carburet manufactured from comparatively pure raw materials, by M. Bullier (according to M. Moissan's process) in the works at Belgard (Ain) will regularly develop 300 litres per kilog. (4 cub. ft. 1400 cub. in. per lb.) of acetylene at 98 per cent.

No prophet is honoured in his own country; this is probably the reason why, in France, the discovery of the industrial process of manufacturing carburet of calcium in the electric furnace is contested to M. Moissan.

In our opinion, however, it is not at all clear that Mr. T. L. Willson can claim priority over our countryman, although on this subject there exists a legend carrying us back to the good old times of alchemy, when Brandt of Hamburg, who experimented on urines in the hope of finding the philosopher's stone, simply succeeded in extracting phosphorus.

Mr. Willson also when trying to produce a preparation of calcium, suited for industrial uses, by treating a mixture of carbonate of lime and anthracite coal in an electric furnace, is said to have obtained a kind of greyish cavernous coke.

This substance, when flung contemptuously into

a trough filled with water, produced a violent disengagement of a gas which the chemist readily recognized as being acetylene; Berthelot had skilfully studied and defined this long before.

Now the story of Brandt, as all the world knows, dates back to 1669, while that of Mr. Willson, much more modern, dates from 1894 only, being the same year in the commencement of which, as we have just stated, M. Moissan described to the Academy of Science the industrial preparation of carburet of calcium with a lavishness of scientific details that precluded any idea of his having stumbled on the discovery by accident.

The partisans of Mr. Willson nevertheless claim that they trace his title to priority in the specification of his patent, of February 20, 1893 (No. 492,376) in which he says—"I have already employed my invention (the electric furnace) for the reduction of oxide of calcium and the production of carburet of calcium." This simple reference to a re-action long known and experimented upon in laboratories, and moreover not backed up by any subsequent publication, nor followed by the appearance, in the market, of any considerable quantities of carburet of calcium, does not by any means prove that the inventor had really *manufactured* any carburet of calcium at that period.

Willson's Patent contains a number of anticipations of which the immediate realization does not appear proved, while the *Comptes rendus de l'Académie des Sciences*, 'Transactions of the Academy of Sciences,' give us a report on experi-

ments under date December 12, 1892, of great industrial importance, having really been made in the course of this year 1892, by M. Henri Moissan.

Properties of Acetylene.—This is, in short, a gas with a smell like garlic, which is the more pronounced in proportion to the impure state of the gas. Its density is 0·90. It is soluble in water to the same extent as carbonic acid, viz. a volume of gas equal to that of water, at ordinary atmospheric pressure, and at a mean temperature of about 28° Centigrade.

Liquefaction.—Like carbonic acid, it will liquefy also, but less readily. Subjoined is a table, according to Ansdelle, of the pressures and corresponding temperatures requisite for its liquefaction—

at 1	atmosphere	(14·7	lbs.	per	sq. in.)	− 82°.20	Cent.
" 9	"	132	"	"	"	− 33°.60	"
" 11	"	162	"	"	"	− 23°.00	"
" 17	"	242	"	"	"	− 10°.00	"
" 21½	"	316	"	"	"	− 0°	"
" 25½	"	375	"	"	"	+ 5°.25	"
" 33	"	485	"	"	"	+ 13°.50	"
" 40	"	588	"	"	"	+ 20°.00	"
Critical point[1]						+ 37°	

We may take it that, roughly speaking, a given volume of liquid acetylene will develop a volume of gas 400 times greater; this figure which, as far as we know, has never been contradicted, is the one stated in the paper read by Mr. Vivian B. Lewes, before the Incorporated Gas Institute, London,

[1] We call "critical point" the limit of temperature beyond which it becomes impossible to liquefy a gas, at any pressure whatever.

and also by Messrs. T. L. Willson and Suckert in their communication to the Franklin Institute at Philadelphia.

Seeing, moreover, that the density of acetylene as determined by M. Berthelot is equal to 0·90, and that a litre of this gas (61 cub. in. of gas weighing 0·654 of a dram) consequently weighs 1·16 gr. under normal conditions of temperature and pressure, it follows that a litre of liquid acetylene will weigh 465 grammes ($1\frac{3}{4}$ pints of acetylene weighing 16 oz. 6 drams), and that consequently 1 kilog. of acetylene would have a volume of about $2\frac{1}{5}$ litres (1 lb. of acetylene will occupy $1\frac{3}{4}$ pints) and disengage 800 or 900 litres of gas (12 cub. ft. 1455 cub. in. to 14 cub. ft. 770 cub. in. of gas).

Lighting.—A burner fed with acetylene without pressure will yield a luminous but smoky flame; if the acetylene is mixed with air in equal volumes it will burn with a reddish flame and smoke more, and if the ratio of air to acetylene is as 1·25 to 1, the mixture will become slightly explosive; this property will be intensified as the proportion of air increases, the maximum of explosiveness being attained when the compound contains one part of acetylene to twelve parts of air.

The lighting experiments made by Mr. Vivian B. Lewes, with a Manchester two-hole No. 00 burner, enabled him to determine that the acetylene flame becomes steady and very brilliant, owing to the current of air set up, if the gas is emitted under a pressure equal to 4 in. of water, or even to 1 in. only; under these circumstances, with a burner

consuming 140 litres (about 5 cub. ft.) per hour (and which with ordinary gas is supposed to emit 16 candle-powers), a light of 240 candles will be obtained.

Messrs. Willson and Suckert on their part suggest that acetylene should be burnt under a pressure equal to 2 in. of water in burners passing 34 litres per hour (1 cub. ft. 350 cub. in.), the light obtained to have a strength of 60 candles; that is to say, the conditions would be about the same as those indicated by Mr. Lewes.

According to these figures the lighting power of acetylene would be about fifteen times as great as that of ordinary gas. But this is not the sole advantage resulting from its use. The proportion of oxygen required for the combustion of this small quantity of acetylene is one-sixth only of that consumed in producing a corresponding light with ordinary gas, and the products of combustion are less in the same proportion, hence the surrounding atmosphere is not vitiated to the same degree.

Finally an acetylene flame would produce a heating effect of 900° Centigrade only where a gas-flame of equal luminous intensity would yield 1400°.

Acetylene, for use in motors, has hitherto been studied far less than for lighting purposes. However, taking the estimate given by Mr. Vivian B. Lewes as a basis, viz. that the maximum power is produced by the detonation of a mixture of one volume of acetylene to twelve volumes of air, we may draw an inference therefrom, seeing that a

maximum explosion, in the case of ordinary gas, is obtained with one volume of gas to six volumes of air.

Under these conditions it is natural to suppose that a given volume of acetylene is capable of producing an amount of energy at least twice as great as can be obtained from the same volume of ordinary lighting-gas.

M. Le Châtelier has made various experiments on mixtures of air and acetylene, from which he has inferred, as Mr. V. B. Lewes had before him, that a mixture of 1·25 parts of acetylene and one part of air commences to be explosive, that the explosive force increases as the admixture of air is increased, that the maximum is obtained with twelve parts of air to one of acetylene, and that beyond this ratio the explosive force decreases, the compound ceasing to be explosive when the proportion of twenty-five volumes of air to one of acetylene is reached.

The velocity of propagation of the flame is said to be 0·18 metres (7 in.) per second for a mixture of 2·9 parts to 100 of air; with 6 to 100 the velocity is 5 metres (16 ft. 5 in.) and 10 to 100 it is 6 metres (19 ft. 8 in.), which is the maximum limit.

The temperature of inflammation (flashing point) is somewhere about 480° Centigrade, that is to say, much lower than in the case of other inflammable gases, for most of which it is 600° Centigrade. Explosive mixtures of acetylene, enclosed in glass tubes, may very readily be ignited by heating the tubes for a few moments over a spirit lamp; the

explosion ensues a good time before the softening of the glass.

The temperature of combustion is much higher than for any other gas; burnt with an equal volume of oxygen it would yield a temperature of about 4000° C., that is to say, 1000° more than for the oxyhydrogen compound.

In fine, acetylene, according to these observations, may be said to present the following properties:—

1. Great velocity in the propagation of the flame.

2. Very low temperature of inflammation.

3. Very high temperature of combustion.

4. Extraordinary energy of explosion.

M. Lothar Meyer has pointed out the dangerous nature of explosive compounds of acetylene. He thinks that as this gas contains a lower proportion of hydrogen than other hydrocarburets, the combustion of the mixture will yield less steam and more carbonic acid, which circumstance, coupled with exceedingly high temperature, generated by the combustion, will explain the extraordinary energy developed by the explosion of acetylene, which produces a very sudden and one might say fulminating explosion.

The ignition, by an electric spark, in an unstoppered bottle turned upside down, of a mixture of air and acetylene in equal volumes, will produce a violent explosion, accompanied by a yellowish-white, very brilliant flame, the bottle (of glass one-twenty-fifth or one-eighth of an inch thick) being

shattered, which result, as we know, will not ensue with the customary mixtures of air and coal-gas, or even of oxygen and hydrogen.

For this reason it would not be prudent to trace leakages of acetylene gas with the aid of a lighted candle as is often done in the case of coal-gas, seeing that the rapid dilution of acetylene will instantaneously result in a detonating mixture of a violently explosive nature.

CHAPTER XX

ACETYLENE AS A MOTOR; LIQUID OR GASEOUS

THE first practical discussions of the use of acetylene as a generator of motive power will be found in an article which appeared last year in the *Journal für die Gasbeleuchtung und Wasserversorgung* (German 'Gas-lighting and Water-supply Journal'), over the signature of Mr. A. von Thering, architect at Aix. He there reports on certain experiments made by Professor Slaby, appending thereto his own personal ideas as to the suitable ways and means for producing motive power by the use of acetylene.

Mr. von Thering believes that through free competition we should certainly manage, eventually, to produce carburet of calcium at the price of 90*s.* (112 fr. 25 c.) per 1000 kilogs. (per ton), and he considers this very gratifying, seeing that carburet of calcium is a very powerful and at the same time very portable storer of energy, with the aid of which the production of motive power could be arranged for in localities most remote from industrial centres.

Mr. von Thering even suggests preparing acetylene first in the liquid state and then conveying the energy available therein in this form.

Dr. Ad. Frank of Charlottenburg does not agree with him, nor do we; it is preferable from every point of view to convey the "condensed motive power" in a solid form in the shape of carburet of calcium.

We may assume, in fact, that 100 kilogs. (2 cwt.). of carburet of calcium will yield 30 cub. metres (1060 cub. ft) of acetylene, and it is easy to calculate the space occupied, on the one hand, by these 100 kilogs. of carburet (2 cwts.) and on the other hand by 30 cub. metres (1060 cub. ft.) of acetylene, in the liquefied state, knowing that the density of liquefied acetylene is 451, while that of solid carburet is 222. The volume of carburet of calcium, per 100 kilogs. (2 cwts.) would be 45 litres (10 gallons), while 30 cub. metres (1060 cub. ft.) of acetylene, if liquefied, weighing about 35 kilogs. (77 lbs.) will occupy a volume *theoretically* equal to 77 litres (17 gallons).

The actual volume of the liquefied acetylene would probably attain 100 litres (22 gallons), or more than twice that of the carburet of calcium, if allowance is made for the very strong and hence very thick vessels in which the liquid acetylene would have to be stored, without however being certain of avoiding all risk of explosion, whilst the carburet can be packed with complete safety in simple tin-boxes.

As regards weight, the total weight of the carburet, with the tins, could scarcely exceed 110 kilogs. (2 cwts. 18 lbs.), while that of the liquid acetylene, with the vessels containing it, could not fall far

short of 300 kilogs. (6 cwts.). A comparison between coal, liquid acetylene, and carburet of calcium, with regard to the respective weights and volumes of the supplies required for working any auto-car for a given period, is now easy enough.

Let us consider, for instance, the case of the run from Paris to Bordeaux and back, with the maximum time of 100 hours allowed for completing the journey, and assuming the auto-car in question to be driven by a 10 H.P. motor worked—

(1) with coke;
(2) with carburet of calcium;
(3) with liquefied acetylene.

(1) **Coke.**—The "Serpollet" system consumes 2 kilogs. (4½ lbs.) of coke per H.P., or for 100 hours and for 10 H.P. about 2 tons of coke, which would occupy a volume of about 4 cub. metres (140 cub. ft.).

(2) **Carburet of Calcium.**—Assuming a kilog. (2¼ lbs.) of carburet of calcium to suffice for the production of 2 H.P., the quantity required for developing 10 H.P., during 100 hours, would be 500 kilogs. (10 cwts.), which could be stowed in a space = 300 litres (66 gallons).

(3) **Liquid Acetylene.**—According to Mr. Slaby we must reckon on a consumption of about 180 grammes (6½ oz.) of liquid acetylene per H.P. per hour, which equals, very nearly, the hypothetical consumption of 150 litres (5 cub. ft. 510 cub. in.) of gaseous acetylene.

Hence the 10 H.P. would consume in 100 hours 180 kilogs. (3½ cwts.) of acetylene, which, in the liquid state including the vessels containing it, would occupy a volume of close on 500 litres (110 gallons), and would represent a total weight of about 1500 kilogs. (129½ cwts.).

The comparison therefore appears to be altogether in favour of carburet of calcium, both as regards bulk and the weight to be carried.

Carburet of calcium is, apart from petroleum, the only source of motive power that would have enabled an auto-car to cover the distance from Paris and back (1200 kilogs. = 745 miles), while carrying with it the whole store of energy required for the whole journey; but petroleum retains the advantage over acetylene as regards facility of renewing supplies.

Acetylene, on the other hand, seems preferable if we consider the cleanliness of its manipulation the impossibility of accidents through catching fire, and the absence of bad smells from the exhaust.

Hence it would seem that petroleum is preferable for travelling in the open country, while acetylene would form the most suitable combustible for travelling in towns—competing advantageously with electricity, both for motive power and for lighting purposes.

Acetylene was tried for the first time in a detonating motor in June last, by M. Pierre Ravel (of whom we have already had occasion to speak to our readers); in this system ignition is effected by the electric spark, which alone per-

mits of regulating the moment of ignition to a nicety.

The results of these trials were communicated on June 17 to the "Congress of Technical Associations of the Gas Industry in France."

M. Ravel was led to make experiments as to the motive power developed by acetylene for various reasons, the primary one being that as this gas was in fashion it was necessary to hasten its study while it was occupying the attention of the public. Moreover, in studying the auto-car question, all explosives must necessarily be interesting, and he was not at all averse to testing for himself the more or less fantastical and often contradictory assertions of American and German journals.

The apparatus for generating acetylene, adopted by M. Ravel, was that of M. Victor Fournier, which he considers the most practical of its kind. It consists of a hermetically closed cylindrical box into which the carburet of calcium is put; this generator is mounted immediately on the bell of a small gas-holder; a pipe connects the two.

A water-reservoir (open to the air) is placed near the gas-holder a little above the level of the well. A rubber tube connects the water-reservoir with the bottom of the generator. The start is effected by opening the reservoir cock; the water comes into contact with the carburet of calcium, and consequently acetylene gas is rapidly disengaged with a large development of heat, and the gas-holder bell is made to rise; when it has attained a certain height, assuming the production

to exceed the consumption, the water will cease to enter, and consequently the formation of gas will, or theoretically should, cease. The output of the motor being fairly large as compared with the volume of the gasometer, there was consequently no reason to trouble too much about this question of apparatus; and in fact this was not the main object of the experiments.

The pressure of the acetylene gas at the gasholder outlet equalled from 160 to 165 millimetres ($6\frac{5}{16}$ to $6\frac{1}{2}$ in.) of water.

The motor used by M. Ravel was one of his own, worked by M. Houpied, manager of the Compagnie des Moteurs Parisiens. This motor acts in two cycles, with compression which may be varied from 2·5 to 3 kilogs. (36 to 43 lbs. per square inch). It presents all the features required for good practical working, and these trials have served to establish the great strength of its constituent parts.

The ignition takes place by electric spark, which alone permits of regulating the exact moment of ignition. M. Ravel had inserted between the motor and the gasometer an experimental meter made by Messrs. Brunt, which stood its trial both as regards regular action and exact measuring.

M. Ravel, who at first did not contemplate anything beyond experimenting with acetylene, came to the conclusion that it might be preferable to determine the results given by this gas as compared with those of another explosive gas. This is the reason why, as his motor, which could

be worked at will either with ordinary gas or with mineral essence, weighing from 710 to 720 grammes ($7\frac{1}{10}$ to $7\frac{1}{5}$ lbs. per gallon), M. Ravel after every trial with ordinary gas made a corresponding trial with acetylene, and he took diagrams of each. He carefully examined the various joints as well as the tightening of the screws, and he thereupon set the motor working with acetylene in the first place.

The first revolutions caused sharp metallic reports to be heard, which caused the motor to vibrate in an alarming manner; while the first diagram was being taken the lever of the indicator was bent by the violence of the shock, an indication which was not devoid of interest, giving, so to speak, a diagram of warning. Finally, after due repair, and with increased precautions, M. Ravel was in a position to commence serious trials.

TABLE OF TRIALS MADE WITH ACETYLENE.

Nos. of Diagrams.	Revolutions per Minute.	Performance Indicated.	Gas per Hour.	Foot-pounds per Cubic Foot.	Proportions of Acetylene per cent.	Compression.
		Foot-pounds.	Cubic Feet.			Lbs. per Square Inch
3	314	1234	$27\frac{1}{2}$	$177\frac{1}{2}$	3·45	43
5	322	—	33	—	4·	—
6	320	—	$33\frac{1}{2}$	—	4·10	—
7	314	1212	$26\frac{1}{4}$	$207\frac{1}{2}$	3·30	32
8	316	1292	$28\frac{3}{8}$	215·60	3·50	—

Course of the Experiments.—M. Ravel in the first place recorded several general observations—

(1) The habitual lubrication of the cylinder when working with coal-gas had to be doubled when working with acetylene gas.

(2) The degree of cooling of the cylinder exerts a greater influence on the work done than when the cylinder works with coal-gas. Under these conditions, and in order to ensure the greatest possible accuracy of the results, M. Ravel adopted as a basis for the calculations, the number of indicated kilogrammetres produced by one litre of acetylene consumed in one hour.

The diagrams shown in Figs. 91, 92 under Nos. 3, 7, and 8, were given by the motor when worked with acetylene, and the diagrams marked 3 *bis*, 7 *bis*, and 8 *bis*, are for the motor when working with coal-gas under the same condition as to speed and charge (Figs. 91, 92).

We thus have, on the one hand, a graphic illustration and juxtaposition of the mode of working manufactured by coal-gas and by acetylene respectively, and on the other hand we may see from the table given that the indicated performance decreases with the proportion of acetylene.

The initial pressure increases with the volume of the doses of acetylene, but an inspection of the diagrams shows that the falling off of the pressure is immediate; the expansion is not sustained. They also show that when the proportion of acetylene approached 5 per cent., the explosions become very violent, and consequently the vibrations of

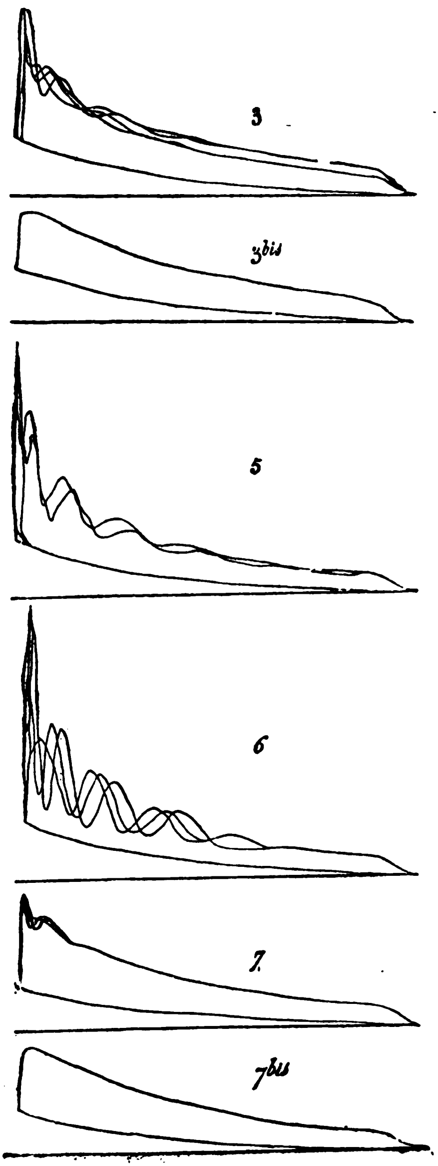


FIG. 91.—Trials with explosive acetylene mixtures, in a detonating motor, by M. Ravel.

the indicator lever give uncertain indications (Nos. 5 and 6).

M. Ravel thinks he has cause to believe, from his numerous experiments made with detonating mixtures, that the explosive charge is subject to internal vibrations during its combustion, which are visible in Nos. 5 and 6.

In order to attenuate them he increased the total volume and the charge at the moment of

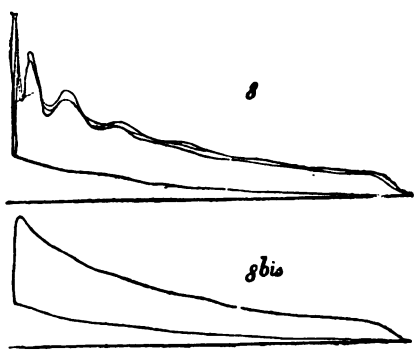


FIG. 92.—Continuation of M. Ravel's diagrams.

ignition, that is to say, that the volume of residues was augmented, but the compression reduced. The diagram shown under Nos. 7, 7 *bis* and 8, 8 *bis* in Figs. 91 and 92, have been obtained under these conditions.

M. Ravel concluded from these experiments that one litre of acetylene will produce on the piston of a motor of the 2 H.P. type, an effort equal to 820 to 870 indicated kilogrammetres (5930 foot-pounds to 6290 foot-pounds). For

purposes of comparison we must mention that in the motor with which the experiments were made, the normal consumption for two effective powers is from 940 to 960 litres of gas (33 to 34 cub. ft.) per H.P.; the average motive power is therefore 405 indicated kilogrammetres per litre (103 foot-pounds per cub. ft.) of gas.

In the case of this small motor the power generated by acetylene would be 2·10 times that of gas, and the consumption per effective H.P. per hour would be 453 litres (16 cub. ft.) of acetylene at a pressure of 160 millimetres ($6\frac{5}{16}''$) of water, representing a volume of about 460 litres ($16\frac{1}{4}$ cub. ft.) at atmospheric pressure, or expressed by weight, 550 grammes ($19\frac{1}{2}$ oz.). In large motors the useful effect would be greater, but the proportion would remain essentially the same.

There remains the economical question as to the cost price of acetylene, and also as regards the homogeneousness of the carburet of calcium.

In fine, M. Ravel does not believe that the great explosive force of acetylene could produce its full useful effect on the pistons of detonating gas-motors as they are constructed at present.

This conclusion is one that we cannot but endorse, more especially as regards the propulsion of auto-cars, as for a long time past we have been convinced that the builders of horseless cars driven by detonating motors are on the wrong track.

Hence the advancement of the question can only gain by the study of absolutely new systems of motors, which, being specially suited for utilizing

the explosive properties of acetylene, will also be able to give better results with compounds of ordinary coal-gas or petroleum vapours.

Acetylene Cars.—Properly speaking there do not exist, as yet, at the present moment, any acetylene cars which have stood the test of actual work.

Richard's patent, taken out on July 26, 1895 (No. 249,207), is, as far as we know, the first in this direction. It is entitled—Application of acetylene for driving auto-cars, boats, etc.

We should have much liked to give our readers a description of this system, but the inventor himself has requested us to do nothing of the kind; this was an additional reason for us not to depart from the rule which we have generally followed throughout this work, of not describing any vehicle, except such as have stood their trials on the road.

Messrs. Ugo Baldini and Quaglia, the former engineer of the Southern Railway at Verona, and the latter a medical man at Turin, four months ago jointly took out a patent for an acetylene motor suitable for purposes of locomotion.

This apparatus is said to present ingenious and novel features; its action is said to be in two cycles, and it is of comparatively light weight; a 3 H.P. motor running at 180 revolutions is said to weigh 50 kilogrammes (1 cwt.) only, and to consume about 200 litres (7 cub. ft.) of acetylene per H.P. per hour.

The compression of the compound is said to be obtained in an ingenious manner by utilizing the

pressure naturally obtained through the disengagement of acetylene, and adding thereto the requisite air compressed separately by means of an auxiliary pump. The transmission of power to the driving-axle is said to be effected without the intervention of belts, gearings, or the like.

These few particulars, which we willingly credit because they have been given us by Sig. Emilio Castelfranco, an engineer of Modena, are calculated to raise some hopes, but do not constitute an established fact, and we cannot in this case act otherwise than we have always hitherto done on similar occasions, viz. defer to a future edition the pleasure of entertaining our readers by describing the acetylene car of Messrs. Baldini and Quaglia.

CONCLUSIONS

THE very remarkable report published by Messrs. Barrett, Lundie and Summers, engineers, on the cars entered for the Chicago-Waukegan race, furnishes, with special reference to auto-cars driven by hydrocarburet motors, certain conclusions which naturally suggest themselves on simply glancing at the table on next page, which brings under the eyes of our readers the most interesting of the very numerous figures which these engineers have determined or obtained by calculation.

The output of explosive motors rapidly diminishes with the performance produced, and this is particularly true as regards auto-cars in which the proportion of force required to overcome resistance is considerable, and the action of which is subject to very considerable and very frequent disturbances.

In order to exercise usefully an effort of one H.P. (75 kilogrammetres = 540 foot-pounds) at the tyre of the driving-wheels, we must resign ourselves to seeing at least 50 kilogrammetres (= 360 foot-pounds) absorbed in order to overcome resistance, that is to say, that the engine must develop one and two-thirds H.P.; the result is that for

Names of Competitors.	Traction effort, foot-pounds.	Speed per hour in miles.	Force in H.P.				Cost per H.P. at the tyre.	
			At the tyre.	Absorbed by the mechanism.	Total indicated.	Output.	*s.*	*d.*
Compagnie de la Vergue	123	7·15	0·70	0·70	1·40	0·50		4
	170	11·18	1·57	1·40	2·97	0·53		3½
Duryea	290	4·81	1·15	0·55	1·70	0·65		2½
Haynes and Aperson	75	4·25	0·20	0·67	0·87	0·30	1	9
	130	9·70	0·95	1·28	2·23	0·43		6
Lewis	309	4·04	0·25	0·65	0·90	0·28		6½
	201	5·60	0·53	1·03	1·56	0·34	1	0
Macy (Benz-Roger)	171	5·82	0·83	1·48	2·31	0·36		4
	286	10·56	2·50	2·68	5·18	0·48		2
Mueller (Benz-Mueller)	141	4·72	1·18	0·61	1·79	0·66		3
	242	11·18	2·18	1·57	3·75	0·58		1½

light work the quantity of gasoline expended per H.P. per hour is four times that which would be required for heavy work, in the case of a very heavily loaded car, or when having to climb hills.

Messrs. Barrett, Lundie and Summers have also studied the resistances to be overcome in the movement of the axles under identical conditions as to running and lubrication, according to the nature of the tyre, and the result was as follows—

With steel tyre, 18·7 kilogs. (266 lbs.).

With solid rubber tyre, 7·2 kilogs. (102 lbs.).

With pneumatic tyre, 5·7 kilogs. (81 lbs.).

The advantage of pneumatics has therefore been

clearly established, and according to American experts this is due to the ease with which these tyres yield to inequalities of the road, a circumstance which reduces the lateral resistance of the wheels and the frictions due to jolting.

These results clearly indicate the course to be followed, viz. to design motors so that transmissions of power are reduced to a minimum, and that, further, they can be effected without any jerks, and the use as far as possible of pneumatic tyres.

Nevertheless, auto-locomotion remains pre-eminently a French industry; the proof thereof is to be found in the very poor results produced by the Americans in spite of considerable efforts—results so poor that they have not ventured to start a single one of their cars in the run to Marseilles.

It is French both by origin as well as by the relative perfection of the results obtained in our country, where it has certainly achieved the highest degree of development hitherto reached.

But how far is this development, which we describe as "relative perfection," by way of homage to the conscientious efforts of our compatriots, still removed from the mechanical perfection which must be striven for!

In fact, our makers are under no illusion in this respect; they are striving with energy and perseverance, and their efforts are sure to lead to successful results.

But let them quicken their pace, for on the other side of the Channel, the nation, which is our antagonist and our great rival, freed at last from

her trammels, thanks to the persevering efforts of Sir David Salomons, is about to enter the lists in earnest, and to confront us with a formidable competition.

That English makers are determined to set out boldly in the new line opened to their industry is loudly proclaimed by the self-eloquent emblem chosen by the most powerful among the Companies recently formed for the construction of auto-cars, namely, the British Motor Syndicate.

May this emblem therefore be ours too, even more appropriately than theirs, and may we, with greater determination and speed, show a good lead on the track of the winged car.

THE END

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